COMTECH EF DATA ™

SLM-5650

Satellite Modem
Installation and Operation Manual

Part Number MN/SLM5650.IOM   Revision 2

Errata A
Comtech EF Data Documentation Update

Subject: Changes to Front Cover and Section B.4, Basic Protocol

Date: October 15, 2007
Original Manual   MN/SLM5650.IOM   Rev 2
Part Number/Rev:
Errata Number: ER-SLM5650.EA2

Agile Document ID   ER-SLM5650.EA2   **Agile CO Number**   CO1453

Change Specifics:

This information will be incorporated into the next revision.

Front Cover – Removed "Preliminary".

B.4   Basic Protocol

Whether in EIA-232 or EIA-485 mode, all data is transmitted as asynchronous serial characters, suitable for transmission and reception by a UART. In this case, the asynchronous character format is 8N1. The baud rate may vary between 2400 and 57,600 baud.

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Errata B
Comtech EF Data Documentation Update

Subject: Changes to **Chapter 2. Installation**

Date: October 9, 2008

**Original Manual
Part Number/Rev:**   MN/SLM5650.IOM   Rev 2

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Change Specifics:

In **Chapter 2. INSTALLATION**, Sect. 2.3.8 Auxiliary Connector (J9), Page 2-9: Revise the pinout table for the 15-pin connector as follows:

From: **To:**

Pin #	Signal Function	Name
1	Chassis Ground	GND
2	Spare	
3	Demod Q channel	Q
4	AGC Monitor test point	AGC
5	Tx TTL fault	TxFLT
6	Spare	
7	Ext carrier off	EXT
8	Demod I channel	I
9	Rx TTL fault	RxFLT
10		
11		
12		
13		
14		
15		

Pin #	Signal Function	Name
1	Demod I Channel	I
2	Spare	
3	Spare	
4	Reserved for Redundancy Switch	
5	Chassic Ground	GND
6	Demod Q Channel	Q
7	AGC Monitor Test Point	AGC
8	Spare	
9	Reserved for Redundancy Switch	
10	Ext Carrier Off	EXT
11	Reserved for Redundancy Switch	
12	Reserved for Redundancy Switch	
13	Tx TTL Fault	TxFLT
14	Rx TTL Fault	RxFLT
15	Reserved for Redundancy Switch	

This information will be incorporated into the next manual revision.

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SLM-5650

Satellite Modem
Installation and Operation Manual

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5. Ship the product back to Comtech EF Data. (Shipping charges should be prepaid.)

For more information regarding the warranty policies, see Warranty Policy, p. xiii.

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About this Manual

This manual describes the installation and operation for the Comtech EF Data SLM-5650 Satellite Modem. This is a technical document intended for earth station engineers, technicians, and operators responsible for the operation and maintenance of the SLM-5650.

Related Documents

The following documents are referenced in this manual:

- Department of Defense (DOD) MIL-STD-188-114A, *Electrical Characteristics of Digital Interface Circuits*

- Comtech EF Data *Specification SP/11226*

- *INTELSAT Earth Station Standards 308 and 309*

- *EUTELSAT SMS*

Conventions and References

Cautions and Warnings

CAUTION indicates a hazardous situation that, if not avoided, may result in minor or moderate injury. CAUTION may also be used to indicate other unsafe practices or risks of property damage.

WARNING indicates a potentially hazardous situation that, if not avoided, could result in death or serious injury.

IMPORTANT indicates a statement that is associated with the task being performed.
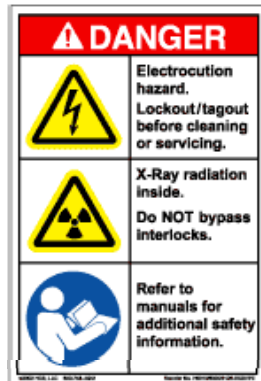
Examples of Multi-Hazard Formats

Metric Conversion

Metric conversion information is located on the inside back cover of this manual. This information is provided to assist the operator in cross-referencing English to Metric conversions.

Recommended Standard Designations

Recommended Standard (RS) Designations are equivalent to the designation of the Electronic Industries Association (EIA). Comtech EF Data will reference only one designator throughout the manual.

Military Standards

References to "MIL-STD-188" apply to the 114A series (i.e., MIL-STD-188-114A), which provides electrical and functional characteristics of the unbalanced and balanced voltage digital interface circuits applicable to both long haul and tactical communications. Specifically, these references apply to the MIL-STD-188-114A electrical characteristics for a balanced voltage digital interface circuit, Type 1 generator, for the full range of data rates. For more information, refer to the Department of Defense (DOD) MIL-STD-188-114A, *Electrical Characteristics of Digital Interface Circuits*.

Trademarks

Product names mentioned in this manual may be trademarks or registered trademarks of their respective companies and are hereby acknowledged.

Revision 2 Highlights

- Incorporated engineering changes throughout the manual.
- Revised Chapter 4, Front Panel Operation.
- Revised Appendix D, Ethernet Management.
- Revised Appendix E. 10/100/1000 Base-T (GbE) Interface

European EMC Directive

In order to meet the European Electro-Magnetic Compatibility (EMC) Directive (EN55022, EN50082-1), properly shielded cables for DATA I/O are required. More specifically, these cables must be shielded from end-to-end, ensuring a continuous ground shield.

The following information is applicable for the European Low Voltage Directive (EN60950):

<HAR>	Type of power cord required for use in the European Community.
⚠	CAUTION: Double-pole/Neutral Fusing ACHTUNG: Zweipolige bzw. Neutralleiter-Sicherung

International Symbols:

∼	Alternating Current.
⊟	Fuse.
⏚	Safety Ground.
⏛	Chassis Ground.

Note: For additional symbols, refer to "Cautions and Warnings" listed earlier in this preface.

Warranty Policy

This Comtech EF Data product is warranted against defects in material and workmanship for a period of one year from the date of shipment. During the warranty period, Comtech EF Data will, at its option, repair or replace products that prove to be defective.

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The foregoing warranty shall not apply to defects resulting from improper installation or maintenance, abuse, unauthorized modification, or operation outside of environmental specifications for the product, or, for damages that occur due to improper repackaging of equipment for return to Comtech EF Data.

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Disclaimer

Comtech EF Data has reviewed this manual thoroughly in order that it will be an easy-to-use guide to your equipment. All statements, technical information, and recommendations in this manual and in any guides or related documents are believed reliable, but the accuracy and completeness thereof are not guaranteed or warranted, and they are not intended to be, nor should they be understood to be, representations or warranties concerning the products described. Further, Comtech EF Data reserves the right to make changes in the specifications of the products described in this manual at any time without notice and without obligation to notify any person of such changes.

If you have any questions regarding your equipment or the information in this manual, please contact the Comtech EF Data Customer Support Department.

Notes:

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Chapter 1. Introduction

This chapter describes an overview of the SLM-5650 Satellite Modem, referred to in this manual as "the modem" (Figure 1-1).

Figure 1-1. SLM-5650

1.1   Introduction

The SLM-5650 satisfies the requirements for applications that require state-of-the-art modulation and coding techniques to optimize satellite transponder bandwidth usage while retaining backward compatibility in government and military communications systems. The initial release of the modem supports base-band data rates up to 51.840 Mbps, and its flexible modulation and **F**orward **E**rror **C**orrection (FEC) capabilities ensure that the throughput and BER over the satellite is optimized.

1.1.1 Features

The modem incorporates the following:

- MIL-STD-188-165A compliant (Types A, B, D, E, F)
- Intel-Sat IESS-308, -309, -310, and -315
- 64 kbps to 52 Mbps (Modulation, code rate, and interface dependent)
- Selectable 70/140 MHz or 950 to 2000 MHz IF interfaces
- BPSK, QPSK, OQPSK, 8-PSK, and 16-QAM
- Adaptive Equalizer for high order modulation types
- FEC Rates: 5/16, 1/2, 2/3, 3/4, 5/6, 7/8, 17/18 and 1/1
- Viterbi and Reed-Solomon Codec
- Turbo Product Codec (Optional)
- EIA-530/422 Data Interface (built in, to 20 Mbps)
- EIA-613/HSSI Data Interface (built in, to 52 Mbps)
- Optional Plug in Data Interface supports Gigabit Ethernet and others
- Data Source Bit Synchronization (Clock recovery for input data without an associated transmit clock)
- Asymmetrical Loop Timing
- Full featured, built-in BER test-set
- Electrical and Ethernet Rx constellation monitor
- EIA-485 and EIA-232 interface for remote control
- Ethernet interface for remote control using HTTP, Telnet, and SNMP
- Flash upgrade capability

The modem is compliant with the provisions of MIL-STD-188-165A, DoD Standard, Interoperability of SHF Satellite Communications PSK Modems (**F**requency **D**ivision **M**ultiple **A**ccess (FDMA) Operation).

The modem is fully interoperable with legacy OM-73 modems and other Government owned **C**ommercial **o**ff-**t**he-**S**helf (COTS) and **I**nternational **T**elecommunications **S**atellite **O**rganization (INTELSAT) compatible PSK modems.

The modem can be controlled and monitored from a variety of platforms, including its own front panel controls and indicators, a co-located **P**ersonal **C**omputer (PC) and remote control systems such as the **C**omtech **M**onitor and **C**ontrol **S**ystem (CMCS) and the **V**ipersat **N**etwork **M**anagement **S**ystem (VNMS).

1.1.2 Options

How Enabled	Option
FAST	Variable data rates from 64 kbps to 5, 10, 20, or 52 Mbps
FAST	8-PSK and 16-QAM
FAST	Turbo Data Rates to 5, 10, 20, and 52 Mbps
FAST	Automatic Uplink Power Control (AUPC)
Hardware	Turbo FEC (Card)
Hardware	Gigabit Ethernet Interface (Card)

1.2   Modem Design

The modem was designed to accommodate a wide range of currently required features and to be able to support both near term and far term advances in both software defined radio technology as well as advances in FEC technology.

The user has the ability to:
- Add or change modular data interfaces and FEC assemblies
- Utilize an extensive array of built in test capabilities
- Be able to easily upgrade the modems capability in the field
- Be able to easily upgrade the modems software in the field
- Have a wide range of flexible remote control options

The user can expect:
- A highly reliable modem
- Low weight and low power dissipation
- A rugged, one-rack unit enclosure that defines state of the art.

The modem is designed for installation in fixed or mobile **E**arth **T**erminal (ET) facilities (sites) using **D**efense **S**atellite **C**ommunications **S**ystem III (DSCS III), DSCS III/**S**atellite **L**ife **E**nhancement **P**rogram (SLEP), **W**ideband **G**ap filler **S**ystem (WGS), and commercial satellites.

1.3   Modem Description

The modem accepts signals from a selected digital signal source and modulates either a 70/140 MHz or L-Band **I**ntermediate **F**requency (IF) carrier with these signals. The demodulator will receive (Rx) a signal from either a 70/140 MHz or L-Band IF input interface, then demodulate the IF carrier. Clock and data are recovered and output on a selected data interface.
The transmit and receive functions are independent with respect to coding, interleaving, overhead, and scrambling. The modem will not allow simplex operation in the 70/140 and simplex operation in the L-Band IF interfaces at the same time. The modem will allow duplex operation in either one of the two IF interfaces.
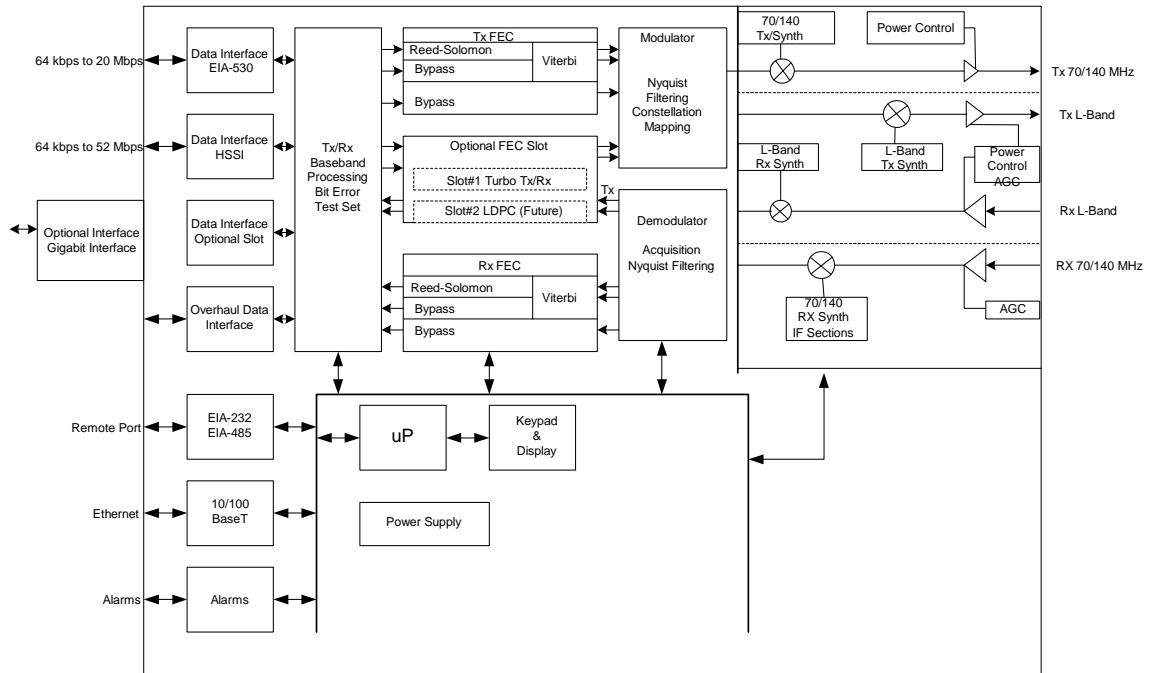
Figure 1-2. SLM-5650 Block Diagram

1.4   Operating Modes

The modem supports **Closed Network, Open Network** and **OM-73** modes of operation
described as follows.

1.4.1 Closed Networks

Closed networks refer to private networks with modem operational parameters that do not need to
interoperate with modems developed for commercial open networks, as specified under the IESS-
308, IESS-309, and IESS-310.

The modem, however, is capable of operating in such closed networks over commercial satellites
IAW INTELSAT requirements for closed network operation.

A Comtech EF Data overhead channel is provided for use during Closed Network operation.

1.4.2 Open Networks (INTELSAT)

Open networks refer to networks that must meet INTELSAT specified **E**ffective **I**sotropic
Radiated **P**ower (EIRP), EIRP stability, spurious emissions, intermodulation products, adjacent
carrier interference, frequency tolerance, equalization, and modem parameters such as
modulation, FEC, and scrambling.

The modem meets INTELSAT certification requirements and is capable of operating in such
open networks over commercial satellites IAW IESS-308, IESS-309, and IESS-310 requirements
for open network operation.

In order to be fully compatible with commercial modems complying with IESS-308, IESS-309,
and IESS-310, the modem supports the overhead framing integral to those modems. It is
important to note that no access to the overhead channel data or alarms is provided.

1.4.3 OM-73

OM-73 mode allows the SLM-5650 to be compatible with Linkabit's original OM-73 modem.
This modem and it's operational capabilities have become a defacto standard when operating
over DSCS satellites. All OM-73 modes listed in MIL-STD-188-165A are supported.

1.5   Data Interfaces

The SLM-5650 supports two native data interfaces as well as a option slot for an additional
modular data interface. The two native interfaces are TIA/EIA-530/422 and TIA/EIA-613
(HSSI). The option interface available at this time is the Gigabit Ethernet. The modem will
currently support only one interface at a time.

1.5.1 TIA/EIA-530

The TIA/EIA-530 interface supports the physical layer requirements for TIA/EIA-530. It also supports the TIA/EIA-422 electrical interface specification. This interface operates in duplex from 64 kbps to 20 Mbps.

1.5.2 TIA/EIA-613 (HSSI)

The TIA/EIA-613 interface supports the physical layer requirements for TIA/EIA-613. It also supports the TIA/EIA-612 electrical interface specification. This interface operates in duplex from 64 kbps to 51.84 Mbps.

1.5.3 Gigabit Ethernet

In the SLM-5650, the GBEI-5650 performs a simple bridge function and passes IP packets, unaltered, in each direction between the LAN (10/100/1000Base-T interface) and WAN (SLM-5650 modulator/demodulator). IP packet traffic is framed via HDLC encapsulation by the GBE-5650 logic, and the GBEI-5650 is both the origination and termination point for HDLC encapsulation. HDLC CRC-16 verification is performed on all received (from WAN) HDLC frames.

1.6   Independent Tx and Rx Function

The Tx (modulator) and Rx (demodulator) sides of the modem are functionally independent and separately controllable. The baseband Tx and Rx sides of a communications channel passing through the modem are independently configurable, including the ability to select different parameters (to include data rate, modulation, and coding) in support of asymmetrical operation.

 Note: Data interfaces and IF interfaces are not independent.

Example: If the TIA/EIA-530 interface is selected **DO NOT USE** TIA/EIA-530 to transmit and a HSSI interface to receive. The same principle applies to the IF interfaces if 70/140 is selected **DO NOT USE** 70/140 to transmit and the L-Band interface to receive.

1.7   Interoperability

1.7.1   Interoperability with Legacy Modems

The modem is fully compatible and interoperable with all specified modes of operation of the following legacy modems:

    a.   OM-73 (V)

    b.   MD-1352 (P)/U (BEM-7650)

    c.   MD-1340 (OM-73 interoperable mode only; orderwire not required)

    d.   MD-1030B
    e.   SLM-3650
    f.   SLM-8650

    g.   SLM-7650

Note: The remote control protocol will not be backwards compatible.

1.7.2   Protection Switches

Redundancy switching is accommodated with the following protection switches.

Compatible	Non-Compatible
CRS-300, 1:10 redundancy switch	SMS-300
CRS-311, 1:1 redundancy switch	SMS-450
	SMS-7000

1.8   Summary of Specifications

Table 1-1. Summary of Specification

Parameter	Specification
Operating Frequency Range	52 to 88, 104 to 176, 950 to 2000 MHz, in 100 Hz steps
Modulation Types	BPSK, QPSK, OQPSK, 8-PSK, 16-QAM
Digital Data Rates	64 kbps to 5 Mbps, in 1 bps steps (EIA-530, EIA-613) 64 kbps to 10 Mbps, in 1 bps steps (EIA-530, EIA-613) 64 kbps to 20 Mbps, in 1 bps steps (EIA-530, EIA-613) 64 kbps to 51.840 Mbps, in 1 bps steps (EIA-613)
Symbol Rate Range	32 Ks/s TO 30 Ms/s
EXT REF Input	TNC Connector, 1, 5, or 10 MHz selectable
INT REF Stability	1×10^{-7}
Scrambling	V.35, OM-73, and Synchronous
IDR/IBS Framing Compatibility	Support for IBS and IDR framing. Allows basic IBS/IDR Open Network capable operation.
Built-in Test (BIT)	Fault and status reporting, BER performance monitoring, IF Loop-back, programmable test modes, built in Fireberd emulation with all comprehensive BER measurements.
Summary Faults	Reported via Front Panel LEDs, 9-pin D sub Alarm connector, relay contacts for Tx, Rx, Common equipment faults, and Tx and RX alarms. Open collector faults on the 15-pin D sub Aux connector. Both data interfaces have open collector faults available.
Monitor and Control	EIA-485, EIA-232, 10/100 BASET Ethernet with HTTP, Telnet, and SNMP.
Modulator Specification	
Output Power	+10 – 40 dBm, adjustable in 0.1 dB steps
Output Return Loss	-14 dB (70/140 MHz) -9 dB (L-Band)
Output Impedance	50 Ω
Spurious	From Carrier $\pm$ Tx SR TO 500 MHz –51 dBc (measured in a 10 kHz bandwidth)
Harmonics	From Carrier (CW) to the greater of the 12th harmonic or 4000 MHz –60 dBc
Tx Clock Source	Rx, INT, Tx Terrestrial, and Data Source Sync
Output Connections	TNC for 52 to 88, 104 to 176 MHz Type N for 950 to 2000 MHz
Modulation Timing Jitter	< 3 % of the modulation symbol period.
Modulation Phase Error	< 2 °
Modulator Spectral Inversion	Modem can invert the modulated spectrum
Transmit Clock and Data Inversion	Modem can invert the Tx clock and data independently of each other. (EIA-530, EIA-613)

Table 1-1. System Specification (Continued)

Demodulator Specification	

Input Power:
    Desired Carrier
    Maximum Composite
	
	+10 to –55 dBm
	+20 dBm or +40 dBc

Input Impedance	50 Ω
Input Connectors	TNC for 52 to 88, 104 to 176 Type N for 950 to 2000 MHz
Carrier Acquisition Range	± 30 kHz, selectable
Input Return Loss	-14 dB (70/140 MHz) -9 dB (L-Band)
Buffer Clock	INT, Tx Terrestrial, Rx Satellite
Doppler Buffer	32 to 4,194,304 bits, selectable in bits or mSec
Coding Options	
Uncoded	1/1
Viterbi	K=7, 1/2, 3/4, and 7/8 rates
Viterbi + Reed-Solomon	Closed Network, per IESS-308, and IESS-309
Trellis	IESS-310
Trellis + Reed-Solomon	IESS-310
Turbo	Turbo Product Coding (TPC), per IESS-315
Open Network Options	
IDR	INTELSAT IESS-308 (Framing only) INTELSAT IESS-310 (Framing only)
IBS	INTELSAT IESS-310 (Framing only) INTELSAT IESS-309 (Framing only)

1.8.1   Performance

1.8.2   Acquisition and Timing Performance Requirements

Note: The following reference Eb/No is defined as the required Eb/No corresponding to a BER of IE-3 with R-S FEC not enabled.

Table 1-2. Acquisition and Timing Performance Requirements

Parameter	Specification
Initial Acquisition	The modem achieves initial acquisition within the times as specified within ± 30 kHz at the reference Eb/No • For baseband data rates between 64 kbps and ≤ 128 kbps, the maximum initial acquisition time is 500 seconds. • For Baseband data rates between 128kbps and ≤ 1544 kbps, the maximum initial acquisition time is 30 seconds. • For baseband data rates > 1544 kbps, the maximum initial acquisition time is 1.5 seconds.
Reacquisition	Reacquisition is achieved, as follows, after a period of up to 15 minutes of the absence of signal when the carrier returns to within 500 Hz of its original frequency. • For baseband data rates between 64 kbps and 128 kbps, the maximum reacquisition time shall be 45 seconds. • For baseband data rates between 128 kbps and 1544 kbps, the maximum reacquisition time shall be 20 seconds. • For baseband data rates greater than 1544 kbps, the maximum reacquisition time shall be 1 second.
BCI	With Tx and Rx random data, the mean time to loss of BCI due to falsely adding or deleting bits is at least 3 days at the reference E_b/N_0. In addition, the modem maintains BCI over 50 consecutive bits of all ones or zeros, which occur no more than once in 10,000 bits, without employing data scrambling.
System Retention	Synchronization and BCI are maintained for all E_b/N_0 above the reference E_b/N_0 (BPSK/QPSK/OQPSK/8-PSK) for signal loss of up to 50 modulation symbol periods, with a probability of at least 90 percent.
Receive Timing Jitter	The Rx output clock peak timing jitter cannot exceed ± 5 percent at the reference E_b/N_0 when the modulated signal meets the modulation timing jitter requirement.
Doppler	The modem meets the requirements with a Doppler shift, rate of change, and acceleration for satellite inclination up to ± 7° as presented in Table A-6, and an additional 0.5 dB added to the reference E_b/N_0.

Table 1-3. Doppler Requirements

Parameter	C-Band	X-Band	Ku-Band	Ka-Band
Doppler Shift in Hz	± 2475	± 3535	± 6045	± 11,810
Doppler Rate of Change in Hz/sec	± 226	± 270	± 490	± 1046
Doppler Acceleration in Hz/sec^2	± 243	± 290	± 526	± 1124

1.8.3 Data Quality Performance

1.8.3.1   OM-73 Compatible Mode Performance

Operating in the OM-73-compatible mode, SLM-5650 BER vs. E_b/N_0 performance with differential encoding and data scrambling enabled does not exceed values shown in Table 1-4 though Table 1-9.

1.8.3.2   MIL-STD-188-165A Compatible Mode Performance

Operating with BPSK, QPSK, or OQPSK modulation in the MIL-STD-188-165A compatible mode, SLM-5650 BER vs. E_b/N_0 performance with differential encoding and data scrambling enabled will not exceed values shown in Table 1-4 (without Reed-Solomon) or Table 1-5 (with Reed-Solomon) tested in an IF back-to-back configuration over the BER range 5×10^{-03} to 1×10^{-07}.

Operating with 8-PSK modulation and rate 2/3 pragmatic trellis coding (without Reed-Solomon outer coding), SLM-5650 BER vs. E_b/N_0 performance is less than or equal to the values shown in Table 1-6 when tested in an IF back-to-back configuration.

Operating with 8-PSK modulation, rate 2/3 pragmatic trellis coding, and Reed-Solomon (219,201) outer coding, SLM-5650 BER vs. E_b/N_0 performance is better than or equal to the values shown in Table 1-7 when tested in an IF back-to-back configuration.

1.8.3.3   IESS-308 Compatible Mode Performance

When operating in the IESS-308 Compatible Mode, SLM-5650 BER vs. E_b/N_0 performance is as specified in IESS-308.

1.8.3.4   IESS-309 Compatible Mode Performance

When operating in the IESS-309 Compatible Mode, SLM-5650 BER vs. E_b/N_0 performance is as specified in IESS-309.

1.8.3.5   IESS-310 Compatible Mode Performance

When operating in the IESS-310 Compatible Mode, SLM-5650 BER vs. E_b/N_0 performance is as specified in IESS-310.

1.8.3.6   16-QAM Coding Mode Performance

The SLM-5650 operating in the 16-QAM mode provides back-to-back BER vs. E_b/N_0 performance better than or equal to the values shown in Table 1-8 when using the modulation formats indicated.

1.8.3.7   Turbo Coding Mode Performance

The SLM-5650 operating in the turbo code mode provides back-to-back BER vs. E_b/N_0 performance better than or equal to the values shown in Table 1-9 when using the modulation formats indicated.

1.8.3.8   BER

1.8.3.8.1   BPSK/QPSK/Offset QPSK BER Performance, Viterbi Decoding

Table 1-4 applies to BPSK, QPSK, and OQPSK rates.

Table 1-4. Viterbi Decoder BER

Eb/No (dB) Specification Viterbi Decoder				
BER	1/2 Rate	3/4 Rate	7/8 Rate	Uncoded
10^{-3}	3.8	5.0	6.3	
10^{-4}	4.7	5.9	7.1	
10^{-5}	5.3	6.6	7.8	10.8
10^{-6}	5.9	7.2	8.4	11.6
10^{-7}	6.5	7.8	9.0	12.4
10^{-8}	7.1	8.3	9.5	13.0

1.8.3.8.2   BPSK/QPSK/Offset QPSK BER Performance, Viterbi Decoding and Reed-Solomon

Table 1-5 applies to BPSK, QPSK, and OQPSK rates.

Table 1-5. Viterbi Decoder with Reed-Solomon BER

Eb/No (dB) Specification Viterbi Decoder with reed-Solomon			
BER	1/2 Rate	3/4 Rate	7/8 Rate
10^{-6}	4.1	5.6	6.7
10^{-7}	4.4	6.0	7.1
10^{-8}	5.0	6.3	7.5

1.8.3.8.3   8-PSK BER Performance, Trellis Decoder

Table 1-6 applies to 8-PSK with trellis decoder rates.

Table 1-6. 8-PSK BER Performance, Trellis Decoder

Eb/No (dB) Specifications Viterbi Decoder		
BER	2/3 Rate	5/6 Rate
10^{-3}	6.5	8.7
10^{-4}	7.3	9.4
10^{-5}	8.1	10.1
10^{-6}	8.9	10.8
10^{-7}	9.6	11.6
1^{0-8}	10.2	12.3

1.8.3.8.4   8-PSK BER Performance, Trellis Decoder and Reed-Solomon

Table 1-7 applies to 8-PSK with trellis decoder and reed-solomon rates.

**Table 1-7. 8-PSK BER Performance,
Trellis Decoder with Reed-Solomon**

Eb/No (dB) Specifications Viterbi Decoder		
BER	2/3 Rate	5/6 Rate
10^{-6}	6.2	8.2
10^{-7}	6.5	8.5
10^{-8}	6.7	8.9
10^{-9}	6.9	9.3
10^{-10}	7.2	9.7

1.8.3.8.5   16-QAM BER Performance, Viterbi Decoder and Reed-Solomon

Table 1-8 applies to 16-QAM with Viterbi decoder and reed-solomon rates.

**Table 1-8. 16-QAM BER Performance,
Viterbi Decoder with Reed-Solomon**

Eb/No (dB) Specifications Viterbi Decoder		
BER	3/4 Rate	7/8 Rate
10^{-6}	8.2	9.5
10^{-7}	8.4	9.8
10^{-8}	8.6	10.1
10^{-9}	8.8	10.3
10^{-10}	9.0	10.6

1.8.3.8.6   BER Performance, Turbo Products Code Decoding

Table 1-9 applies to **T**urbo **P**roducts **C**ode (TPC) decoding rates.

Table 1-9. BER Performance, TPC Decoding

Eb/No (dB) Specification					
	BPSK		**QPSK/OQPSK**		
BER	**21/44**	**5/16**	**21/44**	**3/4**	**7/8**	**17/18**
10^{-6}	3.3	2.5	3.3	3.9	4.3	6.8
10^{-7}	3.4	2.8	3.4	4.1	4.4	7.1
10^{-8}	3.5	3.1	3.5	4.3	4.5	7.4
10^{-9}	3.6	3.4	3.6	4.8	4.6	7.7
10^{-10}	3.7		3.7		4.7	

Eb/No Specification				
	8-PSK			**16-QAM**	
BER	**3/4**	**7/8**	**17/18**	**3/4**	**7/8**
10^{-6}	6.5	7.1	10.0	7.6	8.2
10^{-7}	6.9	7.2	10.6	8.0	8.4
10^{-8}	7.2	7.3	11.2	8.4	8.5
10^{-9}	7.5	7.4	11.8	8.7	8.7
10^{-10}	7.8	7.5		9.0	8.8

1.8.4 BER Performance with Symmetrical Adjacent Carriers

Operating in the presence of two adjacent symmetrical carriers (one lower in frequency and one higher in frequency with same modulation, data rate, and coding), the modem performance is not degraded more than as indicated in Table 1-10, Column three, and a and b. This performance is measured with the adjacent carriers center frequencies offset XR_s Hz from the center frequency of the carrier under test, where X is the spacing factor and R_s is the modulation symbol rate in Hz of the symmetrical carriers.

The BER of the test carrier is measured at the specified carrier Ratio of Energy per Symbol to Noise Power Density in a 1 Hz Bandwidth (E_s/N_0) Carrier to Noise Ratio (C/N) without the adjacent carriers. The adjacent carriers are applied at the specified center frequencies and E_s/N_0 and the BER of the test carrier is measured. The change in BER is equal to the change in E_b/N_0 based on the characterization curve of the test carrier and the amount of **A**djacent **C**hannel **I**nterference (ACI) degradation. For modulation symbol rates below 38.4 ksps, this paragraph does not apply.

Table 1-10. Acceptable ACI Degradation with Spacing Factor of 1.2

Test Carrier E_s/N_0 (dB)	Adjacent Carriers E_s/N_0 (dB)	E_b/N_0 Degradation (dB) Symmetric Case	E_b/N_0 Degradation (dB) Asymmetric Case
5.5	18.5	≤ 0.36	≤ 0.41
6.0	19.0	≤ 0.38	≤ 0.43
8.0	21.0	≤ 0.48	≤ 0.56
8.4	21.4	≤ 0.51	< 0.60
10.0	23.0	≤ 0.64	≤ 0.77
12.0	25.0	≤ 0.88	≤ 1.10
12.7	25.7	≤ 0.99	≤ 1.21

a. For X (spacing factor) = 1.2, the symmetric degradation shall be IAW one of the values in Table 1-17 Column three, and corresponding test carrier E_s/N_0 in Column one. Select a test carrier E_s/N_0 that will yield timely results based on modulation and coding used in the test configuration. The adjacent carriers E_s/N_0 shall be set to corresponding value in Column two.

b. For the case of X (spacing factor) = 1.4, the degradation is less than 0.2 dB.

1.8.5 BER Performance with Asymmetrical Adjacent Carriers

Operating in the presence of two adjacent asymmetrical carriers, one lower in frequency and one higher in frequency, and each adjacent carrier symbol rate (R''_s) = 2.0 R'_s, the modem performance is not degraded more than indicated in Table 1-10, Column four, and a and b. Performance is measured with the adjacent carriers center frequencies offset (X/2) times ($R'_s + R''_s$) Hz from the test carrier center frequency, where X is the spacing factor and R'_s is the modulation symbol rate in Hz of the test carrier, and R''_s is the modulation symbol rate in Hz of each adjacent carrier. For modulation symbol rates below 38.4 ksps, this paragraph does not apply.

    a.   For X (spacing factor) = 1.2, and R''_s = 2.0 R'_s, the asymmetric degradation shall be IAW one of the values in Table 1-10, Column four, and the corresponding test carrier E_s/N_0 in Column one. Select a test carrier E_s/N_0 that will yield timely results based on modulation and coding used in the test configuration. The adjacent carriers E_s/N_0 are set to the corresponding value in Column two.

    b.   For the case of $(1.4/2)(R'_s + R''_s)$ Hz carrier spacing, the degradation is < 0.2 dB.

1.9   Dimensional Envelope

Figure 1-3. Dimensional Envelope

Chapter 2. INSTALLATION

This chapter provides unpacking and installation instructions, system options, and a description of external connections and backward alarm information.

> ⚠️ **CAUTION**
>
> *The equipment contains parts and assemblies sensitive to damage by Electrostatic Discharge (ESD). Use ESD precautionary procedures when touching, removing, or inserting PCBs.*

2.1   Unpacking

The modem and manual are packaged in pre-formed, reusable, cardboard cartons containing foam spacing for maximum shipping protection.

> ⚠️ **CAUTION**
>
> *Do not use any cutting tool that will extend more than 1" into the container and cause damage to the modem.*

To remove the modem:

Step	Procedures
1	Cut the tape at the top of the carton indicated by OPEN THIS END.
2	Remove the cardboard/foam space covering the modem.
3	Remove the modem, manual, and power cord from the carton.
4	Save the packing material for storage or reshipment purposes.
5	Inspect the equipment for any possible damage incurred during shipment.
6	Check the equipment against the packing list to ensure the shipment is correct.
7	Refer to Section 2.2 for installation instructions.

2.2   Installation

2.2.1   Optional Installation of Side-Railings

Install optional side-railings (FP/SL0006), as follows:

Quantity	Part Number	Description
2	FP/SL0006	Side-Railings

Use standard shop tooling. Install the side-railings with customer-furnished standard shop hardware.
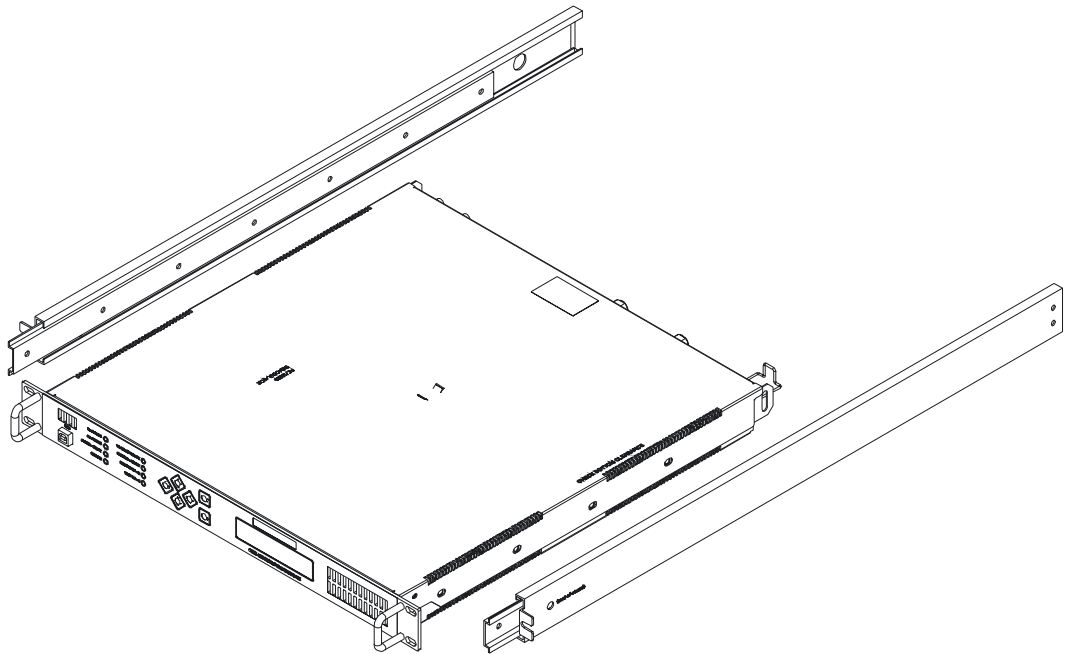
Figure 2-1. Typical Installation of Side-Railings, FP/SL0006

2.2.2   Optional Installation Using a Typical Customer Rack

Step	Procedures
1	Mount the modem chassis in the assigned position of the equipment rack. Support the modem by either a rack-mounted shelf, or the two rear rack-mounted brackets supplied with the unit. **Note:** For a custom rack installation, refer to the rack drawing in Figure 2-1. Additional information can be obtained from Comtech EF Data Customer Support: www.comtechefdata.com
2	Connect the cables to the proper locations on the rear panel.
3	Before turning the power switch on, become familiar with front panel operation in Chapter 4.
4	Turn on the power switch.
5	Check for the proper transmitter (TX) output signal level and spectrum.
6	Check for proper receiver (RX) input signal level and function.
7	If there is any problem with the installation, refer to Chapter 5 for troubleshooting information.
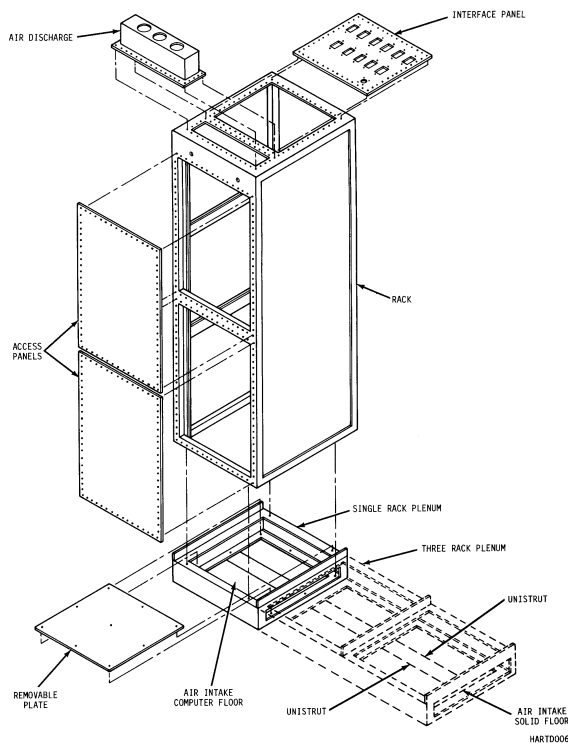
Note: Cool air is drawn in on the left side and hot air is exhausted on the right side.

Figure 2-2. Typical Customized Rack

2.3   External Connections

The connectors on the rear panel of the SLM-5650 are shown in Figure 2-4 and described in the following paragraphs.

Name	Ref Des	Connector Type	Function
EXT REF	J1	TNC	Modem Reference
Tx	J11	TNC	70/140 MHz
Rx	J3	TNC	70/140 MHz
Tx	J2	Type N	L-Band
Rx	J4	Type N	L-Band
Ethernet	J5	RJ-45	10/100 Base-T, Remote Control
EIA-530	J6	25-Pin Female	Data Input /Output, to 20 Mbps
HSSI	J7	52-Pin Female	Data Input /Output, to 52 Mbps
Overhead Data	P1	25-Pin Male	Not Used
Alarms	J8	9-Pin Female	Form-C Alarms
Auxiliary	J9	15-Pin Female	
Remote	J10	9-Pin Female	Remote Interface
AC		IEC	Modem Power
Ground		10-32 stud	Chassis Grounding
Interface Option Slot			Supports optional data interfaces, including but not limited to the Gigabit Ethernet

Note: To maintain compliance with the European EMC Directive (EN55022, EN50082-1) properly shielded cables are required for all data I/O.

Figure 2-3. Rear Panel

2.3.1   External Reference, (J1)

The external reference uses a standard 50 Ω, TNC female connector.

TNC Connector	Reference	Description	Direction
EXT REF	J1	External Reference 1, 5, 10 MHZ	Input

2.3.2   70 / 140 IF Interface Connectors

The 70 / 140 IF use standard 50 Ω, TNC female connectors.

TNC Connector	Reference	Description	Direction
Rx	J3	52-88, 104-176 MHz Receive	Input
Tx	J11	52-88, 104-176 MHz Transmit	Output

2.3.3   L-Band IF Interface Connectors

The L-Band IF uses standard 50 Ω, Type N female connectors.

Type N Connector	Reference	Description	Direction
Rx	J4	950-2000 MHz Receive	Input
Tx	J2	950-2000 MHz Transmit	Output

2.3.4   Ethernet Remote Control Connector, (J5)

The Ethernet connector is an 8-pin 'RJ-45' type 10/100 Base-T. Remote control of the modem is
provided using SNMP, HTTP or Telnet with this port.

2.3.5 EIA-530 Connector, (J6)

The Data connector is a 25-pin 'D' type female (DB25-F). This connector conforms to the EIA-530 pin-out for EIA-422 operation only.

Pin #	Name
1	Ground
14	SD_B
2	SD_A
15	ST_A
3	RD_A
16	RD_B
4	RS_A
17	RT_A
5	CS_A
18	MOD FLT OC
6	DM_A
19	RS_B
7	Ground
20	Not Used
8	RR_A
21	DMD FLT OC
9	RT_B
22	DM_B
10	RR_B
23	Not Used
11	TT_B
24	TT_A
12	ST_B
25	Not Used
13	CS_B

2.3.6 HSSI Connector, (J7)

Notes:
1. 52-pin connector
2. These are non-HSSI defined signals. On Cisco routers there is no connection to those pins.

      Fault => Open
   No Fault => Ground

Pin #	Name
1	Ground
26	Ground
2	RT+
27	RT-
3	CA+
28	CA-
4	RD+
29	RD-
5	Not Used
30	Not Used
6	ST+
31	ST-
7	Ground
32	Ground
8	TA+
33	TA-
9	TT+
34	TT-
10	Not Used
35	Not Used
11	SD+
36	SD-
12	Not Used
37	Not Used
13	Ground
38	Ground
14	Not Used
39	Not Used
15	Not Used
40	Not Used
16	Not Used
41	Not Used
17	Not Used
42	Not Used
18	Not Used
43	Not Used
19	Ground
44	Ground
20	Not Used
45	Demod Fault see Note 2
21	Mod Fault see Note 2
46	Not Used
22	Not Used
47	Not Used
23	Not Used
48	Not Used
24	Not Used
49	Not Used
25	Ground
50	Ground
51	Ground
52	Ground

2.3.7 Alarms Connector, (J8)

The alarm connector provides Form C contact closures for alarm reporting. The three Form C summary fault contacts are Modulator, Demodulator Common Equipment.

The alarm connection is a 9-pin female D connector (J8) located on the rear panel of the modem. Screw locks are provided for mechanical security on the mating connector.

Pin #	Signal Function	Name
8	Unit Alarm is faulted	NO
3	Unit Alarm is not faulted	NC
7	Unit Alarm common	COM
5	Rx Alarm is faulted	NO
9	Rx Alarm is not faulted	NC
4	Rx Alarm common	COM
2	Tx Alarm is faulted	NO
6	Tx Alarm is not faulted	NC
1	Tx Alarm common	COM

2.3.8 Auxiliary Connector, (J9)

The auxiliary connector provides TTL open collector faults for the modulator and demodulator. A TTL input for external transmit carrier mute. An Analog demodulator Q and I constellation monitor. A programmable DC voltage monitor for the demodulators AGC.

(9-Pin Connector) The auxiliary connection is a 9-pin female D connector (J9) located on the rear panel of the modem. Screw locks are provided for mechanical security on the mating connector.

Pin #	Signal Function	Name
1	Chassis Ground	GND
2	Spare	
3	Demod Q channel	Q
4	AGC Monitor test point	AGC
5	Tx TTL fault	TxFLT
6	Spare	
7	Ext carrier off	EXT
8	Demod I channel	I
9	Rx TTL fault	RxFLT

(**15-Pin Connector**) The auxiliary connection is a 15-pin female D connector (J9) located on the rear panel of the modem. Screw locks are provided for mechanical security on the mating connector.

Pin #	Signal Function	Name
1	Chassis Ground	GND
2	Spare	
3	Demod Q channel	Q
4	AGC Monitor test point	AGC
5	Tx TTL fault	TxFLT
6	Spare	
7	Ext carrier off	EXT
8	Demod I channel	I
9	Rx TTL fault	RxFLT
10		
11		
12		
13		
14		
15		

2.3.9 Remote Connector, (J10)

The remote connector is a 9-pin subminiature female D connector (J6) located on the rear panel of the modem. Screw locks are provided for mechanical security of the mating connector.

The remote connector interfaces the M&C functions to a remote location. The remote location can be an M&C computer located away from the modem, but attached via cable to the remote connector. This DCE interface is user selectable for either EIA-232 or EIA-484.

Pinout				
EIA-232		EIA-485		
Pin #	Name	Pin #	Name (2-Wire)	Name (4-Wire)
5	GND	5	-Tx/Rx	-Tx
9		9	-Tx/Rx	-Rx
4		4	+Tx/Rx	+Tx
8	CTS	8	+Tx/RX	+Rx
3	TD	3		
7	RTS	7		
2	RD	2		
6	DSR	6		
1	GND	1		

*For EIA-485 2-Wire Operation:
- Only two wires are required.
- Tie pins 4 and 8 together (both +).
- Tie pins 5 and 9 together (both -).

2.3.10 Overhead Data, (P1)

The overhead interface connector is a 25-pin male D interface located on the rear panel of the modem.

This connector pin-out allows for connection of EIA-422, EIA-485 and EIA-232 data interfaces for use with overhead framing. It also supports signaling for tactical applications

Pin #	Signal Function	Name
1	EIA-422 Transmit Data "A", Input	Tx Data A
14	EIA-422 Transmit Data "B", Input	Tx Data B
2	EIA-422 Transmit Clock "A", Output	Tx Clk A
15	EIA-422 Transmit Clock "B", Output	Tx Clk B
3	EIA-422 Transmit Byte Sync "A", Output	Tx Sync A
16	EIA-422 Transmit Byte Sync "B", Output	Tx Sync B
4	EIA-422 Receive Data "A", Output	Rx Data A
17	EIA-422 Receive Data "B", Output	Rx Data B
5	EIA-422 Receive Clock "A", Output	Rx Clk A
18	EIA-422 Receive Clock "B", Output	Rx Clk B
6	EIA-422 Receive Byte Sync "A", Output	Rx Sync A
19	EIA-422 Receive Byte Sync "B", Output	Rx Sync B
7	Shield	Ground
20	EIA-485 Transmit Data "-"	485 Tx Data -
8	EIA-485 Transmit Data "+"	485 Tx Data +
21	EIA-422 Transmit Handover Sync "A", Input	THS A
9	EIA-485 Receive Data "-"	485 Rx Data -
22	EIA-485 Receive Data "+"	485 Rx Data +
10	EIA-422 Transmit Handover Sync "B", Input	THS B
23	EIA-232 Clear to Send	232 CTS
11	EIA-232 Receive Data	232 Rx Data
24	EIA-232 Request to Send	232 RTS
12	EIA-232 Transmit Data	232 Tx Data
25	EIA-422 Transmit Handover Control "A", Input	THC A
13	EIA-422 Transmit Handover Control "B", Input	THC B

*For EIA-485 2-Wire Operation:
- Only two wires are required.
- Tie pins 8 and 22 together (both +).
- Tie pins 9 and 20 together (both -).

2.4   AC Power Connector

A standard, detachable, non-locking, 3-prong power cord (IEC plug) supplies the Alternating Current (AC) power to the modem. Observe the following:

Input Power	65W maximum, 50W typical
Input Voltage	90 to 132 or 175 to 264 VAC
	Unit switches ranges automatically
Connector Type	I.E.C
Fuse Protection	1A slo-blo
	Line and neutral fusing
	5 mm type fuses

2.5   Ground Connector (GND)

A #10-32 stud on the rear panel of the modem is used for connecting a common chassis ground among all equipment.

Note: The AC power connector provides the safety ground.

2.6   Gigabit Ethernet

The Gigabit Ethernet interface (AS/11985) supports 10/100/1000 BaseT operation. The LAN interface is comprised of one IEEE 802.3ab 1000Base-T copper interface via a single female RJ-45 connector (J1).

Pin #	Description	Direction
1	BI_DA+	bidirectional
2	BI_DA-	bidirectional
3	BI_DB+	bidirectional
4	BI_DC+	bidirectional
5	BI_DC-	bidirectional
6	BI_DB-	bidirectional
7	BI_DD+	bidirectional
8	BI_DD-	bidirectional

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Chapter 3. Configuration

3.1   Modes

The following tables show the various data rate ranges available for various modes.

Table 3-1. OM-73 Mode

Modulation Type	Data Rate (kbps)		Symbol Rate (ksps)	
	Min	**Max**	**Min**	**Max**
BPSK 1/1	64	8472	64	10000
BPSK 1/2	64	15000	128	30000
BPSK 3/4	64	22500	85.333	29999.999
BPSK 7/8	64	26250	73.142	30000
QPSK 1/1	64	20000	32	10000
QPSK 1/2	64	30000	64	30000
QPSK 3/4	64	45000	42.666	30000
QPSK 7/8	64	51840	36.571	29622.857
OQPSK 1/1	64	20000	32	10000
OQPSK 1/2	64	30000	64	30000
OQPSK 3/4	64	45000	42.666	30000
OQPSK 7/8	64	51840	36.571	29622.857

Table 3-2. MIL-STD-188-165A Mode

Modulation Type	R-S Code Word	R-S Depth	Data Rate (kbps)		Symbol Rate (ksps)	
			Min	Max	Min	Max
BPSK 1/1	Off	N/A	64	8472	64	10000
BPSK 1/2	Off	N/A	64	15000	128	30000
BPSK 3/4	Off	N/A	64	22500	85.333	29999.999
BPSK 7/8	Off	N/A	64	26250	73.142	30000
QPSK 1/1	Off	N/A	64	20000	32	10000
QPSK 1/2	Off	N/A	64	30000	64	30000
QPSK 3/4	Off	N/A	64	45000	42.666	30000
QPSK 7/8	Off	N/A	64	51840	36.571	29622.857
OQPSK 1/1	Off	N/A	64	20000	32	10000
OQPSK 1/2	Off	N/A	64	30000	64	30000
OQPSK 3/4	Off	N/A	64	45000	42.666	30000
OQPSK 7/8	Off	N/A	64	51840	36.571	29622.857
8-PSK 2/3	Off	N/A	256	51840	128	25920
8-PSK 5/6	Off	N/A	256	51840	102.4	20736
BPSK 1/2	126,112	4, 8	64	13333.333	144	29999.999
BPSK 1/2	219,201	4, 8	64	13767.123	139.462	29999.999
BPSK 1/2	225,205	4, 8	64	13666.666	140.487	29999.998
BPSK 1/2	220,200	4, 8	64	13636.363	140.8	29999.999
BPSK 3/4	126,112	4, 8	64	20000	96	30000
BPSK 3/4	219,201	4, 8	64	20650.684	92.975	29999.998
BPSK 3/4	225,205	4, 8	64	20500	93.658	29999.999
BPSK 3/4	220,200	4, 8	64	20454.545	93.867	29999.999
BPSK 7/8	126,112	4, 8	64	23333.333	82.826	30000
BPSK 7/8	219,201	4, 8	64	24092.465	79.692	29999.999
BPSK 7/8	225,205	4, 8	64	23916.666	80.278	29999.999
BPSK 7/8	220,200	4, 8	64	23863.636	80.457	30000
QPSK 1/2	126,112	4, 8	64	26666.666	72	29999.999
QPSK 1/2	219,201	4, 8	64	27534.246	69.371	29999.999
QPSK 1/2	225,205	4, 8	64	27333.333	70.243	29999.999
QPSK 1/2	220,200	4, 8	64	27272.727	70.4	30000
QPSK 3/4	126,112	4, 8	64	40000	48	30000
QPSK 3/4	219,201	4, 8	64	41301.369	46.487	29999.999
QPSK 3/4	225,205	4, 8	64	41000	46.829	30000
QPSK 3/4	220,200	4, 8	64	40909.090	46.933	30000
QPSK 7/8	126,112	4, 8	64	46666.666	41.143	30000
QPSK 7/8	219,201	4, 8	64	48184.931	39.846	29999.999
QPSK 7/8	225,205	4, 8	64	47833.333	40.139	29999.999
QPSK 7/8	220,200	4, 8	64	47727.272	40.229	30000
OQPSK 1/2	126,112	4, 8	64	26666.666	72	29999.999
OQPSK 1/2	219,201	4, 8	64	27534.246	69.371	29999.999
OQPSK 1/2	225,205	4, 8	64	27333.333	70.243	29999.999
OQPSK 1/2	220,200	4, 8	64	27272.727	70.4	30000
OQPSK 3/4	126,112	4, 8	64	40000	48	30000
OQPSK 3/4	219,201	4, 8	64	41301.369	46.487	29999.999
OQPSK 3/4	225,205	4, 8	64	41000	46.829	30000
OQPSK 3/4	220,200	4, 8	64	40909.090	46.933	30000

Modulation Type	R-S Code Word	R-S Depth	Data Rate (kbps)		Symbol Rate (ksps)	
			Min	Max	Min	Max
OQPSK 7/8	126,112	4, 8	64	46666.666	41.143	30000
OQPSK 7/8	219,201	4, 8	64	48184.931	39.846	29999.999
OQPSK 7/8	225,205	4, 8	64	47833.333	40.139	29999.999
OQPSK 7/8	220,200	4, 8	64	47727.272	40.229	30000
8-PSK 2/3	126,112	4, 8	256	51840	144	29160
8-PSK 2/3	219,201	4, 8	256	51840	139.462	28241.194
8-PSK 2/3	225,205	4, 8	256	51840	140.487	28448.78
8-PSK 2/3	220,200	4, 8	256	51840	140.8	28512
8-PSK 5/6	126,112	4, 8	256	51840	115.2	23328
8-PSK 5/6	219,201	4, 8	256	51840	111.57	22592.955
8-PSK 5/6	225,205	4, 8	256	51840	112.39	22759.024
8-PSK 5/6	220,200	4, 8	256	51840	112.64	22809.6

Table 3-3. IESS-308 Mode – Standard Higher Rates

Modulation Type	Overhead	R-S Code Word	R-S Depth	Data Rate (kbps)	Symbol Rate (ksps)
QPSK 1/2	IESS-308	Off	N/A	1544	1640
QPSK 1/2	IESS-308	Off	N/A	2048	2144
QPSK 1/2	IESS-308	Off	N/A	6312	6408
QPSK 1/2	IESS-308	Off	N/A	8448	8544
QPSK 1/2	IESS-308	194,178	4, 8, 16	1544	1778.787
QPSK 1/2	IESS-308	194,178	4, 8, 16	2048	2328.09
QPSK 1/2	IESS-308	194,178	4, 8, 16	6312	6975.371
QPSK 1/2	IESS-308	194,178	4, 8, 16	8448	9303.371
QPSK 1/2	IESS-308	219,201	4, 8, 16	1544	1778.269
QPSK 1/2	IESS-308	219,201	4, 8, 16	2048	2327.403
QPSK 1/2	IESS-308	219,201	4, 8, 16	6312	6973.254
QPSK 1/2	IESS-308	219,201	4, 8, 16	8448	9300.537
QPSK 1/2	IESS-308	225,205	4, 8, 16	1544	1790.634
QPSK 1/2	IESS-308	225,205	4, 8, 16	2048	2343.805
QPSK 1/2	IESS-308	225,205	4, 8, 16	6312	7023.805
QPSK 1/2	IESS-308	225,205	4, 8, 16	8448	9368.195
QPSK 1/2	IESS-308	126,112	4, 8, 16	1544	1833
QPSK 1/2	IESS-308	126,112	4, 8, 16	2048	2400
QPSK 1/2	IESS-308	126,112	4, 8, 16	6312	7197
QPSK 1/2	IESS-308	126,112	4, 8, 16	8448	9600
QPSK 1/2	IESS-308	208,192	4, 8, 16	1544	1776.708
QPSK 1/2	IESS-308	208,192	4, 8, 16	2048	2325.333
QPSK 1/2	IESS-308	208,192	4, 8, 16	6312	6966.875
QPSK 1/2	IESS-308	208,192	4, 8, 16	8448	9292
QPSK 3/4	IESS-308	Off	N/A	1544	1029.333
QPSK 3/4	IESS-308	Off	N/A	2048	1365.333
QPSK 3/4	IESS-308	Off	N/A	6312	4208
QPSK 3/4	IESS-308	Off	N/A	8448	5632
QPSK 3/4	IESS-308	Off	N/A	32064	21376
QPSK 3/4	IESS-308	Off	N/A	34368	22912
QPSK 3/4	IESS-308	Off	N/A	44736	29824
QPSK 3/4	IESS-308	194,178	4, 8, 16	1544	1217.858

Modulation Type	Overhead	R-S Code Word	R-S Depth	Data Rate (kbps)	Symbol Rate (ksps)
QPSK 3/4	IESS-308	194,178	4, 8, 16	2048	1584.06
QPSK 3/4	IESS-308	194,178	4, 8, 16	6312	4682.247
QPSK 3/4	IESS-308	194,178	4, 8, 16	8448	6324.247
QPSK 3/4	IESS-308	194,178	4, 8, 16	32064	23393.438
QPSK 3/4	IESS-308	194,178	4, 8, 16	34368	25067.506
QPSK 3/4	IESS-308	219,201	4, 8, 16	1544	1217.512
QPSK 3/4	IESS-308	219,201	4, 8, 16	2048	1583.602
QPSK 3/4	IESS-308	219,201	4, 8, 16	6312	4680.836
QPSK 3/4	IESS-308	219,201	4, 8, 16	8448	6232.358
QPSK 3/4	IESS-308	219,201	4, 8, 16	32064	23386.269
QPSK 3/4	IESS-308	219,201	4, 8, 16	34368	25059.821
QPSK 3/4	IESS-308	225,205	4, 8, 16	1544	1225.756
QPSK 3/4	IESS-308	225,205	4, 8, 16	2048	1594.537
QPSK 3/4	IESS-308	225,205	4, 8, 16	6312	4714.537
QPSK 3/4	IESS-308	225,205	4, 8, 16	8448	6277.463
QPSK 3/4	IESS-308	225,205	4, 8, 16	32064	23557.463
QPSK 3/4	IESS-308	225,205	4, 8, 16	34368	25243.317
QPSK 3/4	IESS-308	126,112	4, 8, 16	1544	1254
QPSK 3/4	IESS-308	126,112	4, 8, 16	2048	1632
QPSK 3/4	IESS-308	126,112	4, 8, 16	6312	4830
QPSK 3/4	IESS-308	126,112	4, 8, 16	8448	6432
QPSK 3/4	IESS-308	126,112	4, 8, 16	32064	24144
QPSK 3/4	IESS-308	126,112	4, 8, 16	34368	25872
QPSK 3/4	IESS-308	208,192	4, 8, 16	1544	1216.472
QPSK 3/4	IESS-308	208,192	4, 8, 16	2048	1582.222
QPSK 3/4	IESS-308	208,192	4, 8, 16	6312	4676.583
QPSK 3/4	IESS-308	208,192	4, 8, 16	8448	626.667
QPSK 3/4	IESS-308	208,192	4, 8, 16	32064	23364.667
QPSK 3/4	IESS-308	208,192	4, 8, 16	34368	25036.667
QPSK 7/8	IESS-308	Off	N/A	1544	882.286
QPSK 7/8	IESS-308	Off	N/A	2048	1170.286
QPSK 7/8	IESS-308	Off	N/A	6312	3606.857
QPSK 7/8	IESS-308	Off	N/A	8448	4827.428
QPSK 7/8	IESS-308	Off	N/A	32064	20040.571
QPSK 7/8	IESS-308	Off	N/A	34368	21473.714
QPSK 7/8	IESS-308	Off	N/A	44736	27922.857
QPSK 7/8	IESS-308	194,178	4, 8, 16	1544	1057.592
QPSK 7/8	IESS-308	194,178	4, 8, 16	2048	1371.48
QPSK 7/8	IESS-308	194,178	4, 8, 16	6312	4027.069
QPSK 7/8	IESS-308	194,178	4, 8, 16	8448	5357.355
QPSK 7/8	IESS-308	194,178	4, 8, 16	32064	20065.233
QPSK 7/8	IESS-308	194,178	4, 8, 16	34368	21500.148
QPSK 7/8	IESS-308	194,178	4, 8, 16	44736	27957.265
QPSK 7/8	IESS-308	219,201	4, 8, 16	1544	1057.296
QPSK 7/8	IESS-308	219,201	4, 8, 16	2048	1371.087
QPSK 7/8	IESS-308	219,201	4, 8, 16	6312	4025.859
QPSK 7/8	IESS-308	219,201	4, 8, 16	8448	5355.736
QPSK 7/8	IESS-308	219,201	4, 8, 16	32064	20059.087
QPSK 7/8	IESS-308	219,201	4, 8, 16	34368	21493.561
QPSK 7/8	IESS-308	219,201	4, 8, 16	44736	27948.691
QPSK 7/8	IESS-308	225,205	4, 8, 16	1544	1064.362
QPSK 7/8	IESS-308	225,205	4, 8, 16	2048	1380.46

Modulation Type	Overhead	R-S Code Word	R-S Depth	Data Rate (kbps)	Symbol Rate (ksps)
QPSK 7/8	IESS-308	225,205	4, 8, 16	6312	4054.743
QPSK 7/8	IESS-308	225,205	4, 8, 16	8448	5394.397
QPSK 7/8	IESS-308	225,205	4, 8, 16	32064	20205.826
QPSK 7/8	IESS-308	225,205	4, 8, 16	34368	26150.843
QPSK 7/8	IESS-308	225,205	4, 8, 16	44736	28153.422
QPSK 7/8	IESS-308	126,112	4, 8, 16	1544	1088.571
QPSK 7/8	IESS-308	126,112	4, 8, 16	2048	1412.571
QPSK 7/8	IESS-308	126,112	4, 8, 16	6312	4153.714
QPSK 7/8	IESS-308	126,112	4, 8, 16	8448	5526.857
QPSK 7/8	IESS-308	126,112	4, 8, 16	32064	20708.571
QPSK 7/8	IESS-308	126,112	4, 8, 16	34368	22189.714
QPSK 7/8	IESS-308	126,112	4, 8, 16	44736	28854.857
QPSK 7/8	IESS-308	208,192	4, 8, 16	1544	1056.405
QPSK 7/8	IESS-308	208,192	4, 8, 16	2048	1369.905
QPSK 7/8	IESS-308	208,192	4, 8, 16	6312	4022.214
QPSK 7/8	IESS-308	208,192	4, 8, 16	8448	5350.857
QPSK 7/8	IESS-308	208,192	4, 8, 16	32064	20040.571
QPSK 7/8	IESS-308	208,192	4, 8, 16	34368	21473.714
QPSK 7/8	IESS-308	208,192	4, 8, 16	44736	27922.857

Table 3-4. IESS-308 Mode - Extended

Modulation Type	Overhead	R-S Code Word	R-S Depth	Data Rate (kbps)		Symbol Rate (ksps)	
				Min	Max	Min	Max
QPSK 1/2	None	Off	N/A	64	30000	64	30000
QPSK 1/2	None	126,112	4, 8, 16	64	26666.666	72	29999.999
QPSK 1/2	None	219,201	4, 8, 16	64	27534.246	69.371	29999.999
QPSK 1/2	None	194,178	4, 8, 16	64	27525.773	69.573	30000
QPSK 1/2	None	225,205	4, 8, 16	64	27333.333	70.243	29999.999
QPSK 1/2	None	208,192	4, 8, 16	64	27559.809	69.667	30000
QPSK 1/2	IESS-309	Off	N/A	64	8448	68.267	9011.2
QPSK 1/2	IESS-309	126,112	4, 8, 16	64	8448	76.8	10137.6
QPSK 1/2	IESS-309	194,178	4, 8, 16	64	8448	74.403	9821.196
QPSK 1/2	IESS-309	225,205	4, 8, 16	64	8448	74.927	9890.341
QPSK 1/2	IESS-309	208,192	4, 8, 16	64	8448	74.311	9809.067
QPSK 3/4	None	Off	N/A	64	45000	42.666	30000
QPSK 3/4	None	126,112	4, 8, 16	64	40000	48	30000
QPSK 3/4	None	219,201	4, 8, 16	64	41301.369	46.487	29999.999
QPSK 3/4	None	194,178	4, 8, 16	64	41288.65	46.502	30000
QPSK 3/4	None	225,205	4, 8, 16	64	41000	46.829	30000
QPSK 3/4	None	208,192	4, 8, 16	64	41339.713	46.444	30000
QPSK 3/4	IESS-309	Off	N/A	64	8448	45.511	6007.467
QPSK 3/4	IESS-309	126,112	4, 8, 16	64	8448	51.2	6758.4
QPSK 3/4	IESS-309	219,201	4, 8, 16	64	8448	49.587	6545.449
QPSK 3/4	IESS-309	194,178	4, 8, 16	64	8448	49.602	6547.464
QPSK 3/4	IESS-309	225,205	4, 8, 16	64	8448	49.951	6593.561
QPSK 3/4	IESS-309	208,192	4, 8, 16	64	8448	49.541	6539.378
QPSK 7/8	None	Off	N/A	64	51840	36.571	29622.857
QPSK 7/8	None	126,112	4, 8, 16	64	46666.666	41.143	30000
QPSK 7/8	None	219,201	4, 8, 16	64	48184.931	39.846	29999.999
QPSK 7/8	None	194,178	4, 8, 16	64	48170.103	38.859	30000
QPSK 7/8	None	225,205	4, 8, 16	64	47833.333	40.139	29999.999
QPSK 7/8	None	208,192	4, 8, 16	64	48229.665	39.81	29999.999
QPSK 7/8	IESS-309	Off	N/A	64	8448	39.01	4827.428
QPSK 7/8	IESS-309	126,112	4, 8, 16	64	8448	43.886	5792.914
QPSK 7/8	IESS-309	219,201	4, 8, 16	64	8448	42.503	5610.385
QPSK 7/8	IESS-309	194,178	4, 8, 16	64	8448	42.516	5612.112
QPSK 7/8	IESS-309	225,205	4, 8, 16	64	8448	42.818	5561.624
QPSK 7/8	IESS-309	208,192	4, 8, 16	64	8448	42.463	5604.181
OQPSK 1/2	None	Off	N/A	64	30000	64	30000
OQPSK 1/2	None	126,112	4, 8, 16	64	26666.666	72	29999.999
OQPSK 1/2	None	219,201	4, 8, 16	64	27534.246	69.371	29999.999
OQPSK 1/2	None	194,178	4, 8, 16	64	27525.773	69.573	30000
OQPSK 1/2	None	225,205	4, 8, 16	64	27333.333	70.243	29999.999
OQPSK 1/2	None	208,192	4, 8, 16	64	27559.809	69.667	30000
OQPSK 1/2	IESS-309	Off	N/A	64	8448	68.267	901.2
OQPSK 1/2	IESS-309	126,112	4, 8, 16	64	8448	76.8	10137.6
OQPSK 1/2	IESS-309	219,201	4, 8, 16	64	8448	74.38	9818.173
OQPSK 1/2	IESS-309	194,178	4, 8, 16	64	8448	74.403	9821.196
OQPSK 1/2	IESS-309	225,205	4, 8, 16	64	8448	74.927	9890.341

Modulation Type	Overhead	R-S Code Word	R-S Depth	Data Rate (kbps)		Symbol Rate (ksps)	
				Min	Max	Min	Max
OQPSK 1/2	IESS-309	208,192	4, 8, 16	64	8448	74.311	9809.067
OQPSK 3/4	None	Off	N/A	64	20000	42.666	30000
OQPSK 3/4	None	126,112	4, 8, 16	64	40000	48	30000
OQPSK 3/4	None	219,201	4, 8, 16	64	41301.369	46.487	29999.999
OQPSK 3/4	None	194,178	4, 8, 16	64	41288.65	46.502	30000
OQPSK 3/4	None	225,205	4, 8, 16	64	41000	46.829	30000
OQPSK 3/4	None	208,192	4, 8, 16	64	41339.713	46.444	30000
OQPSK 3/4	IESS-309	Off	N/A	64	8448	45.511	6007.467
OQPSK 3/4	IESS-309	126,112	4, 8, 16	64	8448	51.2	6758.4
OQPSK 3/4	IESS-309	219,201	4, 8, 16	64	8448	49.587	6545.449
OQPSK 3/4	IESS-309	194,178	4, 8, 16	64	8448	49.602	6547.464
OQPSK 3/4	IESS-309	225,205	4, 8, 16	64	8448	49.951	6593.561
OQPSK 3/4	IESS-309	208,192	4, 8, 16	64	8448	49.541	6539.378
OQPSK 7/8	None	Off	N/A	64	20000	36.571	29622.857
OQPSK 7/8	None	126,112	4, 8, 16	64	46666.666	41.143	30000
OQPSK 7/8	None	219,201	4, 8, 16	64	48184.931	39.846	29999.999
OQPSK 7/8	None	194,178	4, 8, 16	64	48170.103	38.859	30000
OQPSK 7/8	None	225,205	4, 8, 16	64	47833.333	40.139	29999.999
OQPSK 7/8	None	208,192	4, 8, 16	64	48229.665	39.81	29999.999
OQPSK 7/8	IESS-309	Off	N/A	64	8448	39.01	4827.428
OQPSK 7/8	IESS-309	126,112	4, 8, 16	64	8448	43.886	5792.914
OQPSK 7/8	IESS-309	219,201	4, 8, 16	64	8448	42.503	5610.385
OQPSK 7/8	IESS-309	194,178	4, 8, 16	64	8448	42.516	5612.112
OQPSK 7/8	IESS-309	225,205	4, 8, 16	64	8448	42.818	5561.624
OQPSK 7/8	IESS-309	208,192	4, 8, 16	64	8448	42.463	5604.181

Table 3-5. IESS-309 Mode – Extended (Closed Network)

Modulation Type	Overhead	R-S Code Word	R-S Depth	Data Rate (kbps)		Symbol Rate (ksps)	
				Min	Max	Min	Max
BPSK 1/2	None	Off	N/A	64	15000	128	30000
BPSK 1/2	None	219,201	4, 8, 16	64	13767.123	139.462	29999.999
BPSK 1/2	IESS-309	Off	N/A	64	8448	136.533	18022.4
BPSK 1/2	IESS-309	219,201	4, 8, 16	64	8448	148.76	19636.346
BPSK 3/4	None	Off	N/A	64	22500	85.333	29999.999
BPSK 3/4	None	219,201	4, 8, 16	64	20650.684	92.975	29999.999
BPSK 3/4	IESS-309	Off	N/A	64	8448	91.022	12014.933
BPSK 3/4	IESS-309	219,201	4, 8, 16	64	8448	99.173	13090.898
QPSK 1/2	None	Off	N/A	64	30000	64	30000
QPSK 1/2	None	219,201	4, 8, 16	64	27534.246	69.371	29999.999
QPSK 1/2	IESS-309	Off	N/A	64	8448	68.267	9011.2
QPSK 1/2	IESS-309	219,201	4, 8, 16	64	8448	74.38	9818.173
QPSK 3/4	None	Off	N/A	64	20000	42.666	30000
QPSK 3/4	None	219,201	4, 8, 16	64	41301.369	46.487	29999.999
QPSK 3/4	IESS-309	Off	N/A	64	8448	45.511	6007.467
QPSK 3/4	IESS-309	219,201	4,8, 16	64	8448	49.587	6545.449
OQPSK 1/2	None	Off	N/A	64	30000	64	30000
OQPSK 1/2	None	219,201	4, 8, 16	64	27534.246	69.371	29999.999
OQPSK 1/2	IESS-309	Off	N/A	64	8448	68.267	9011.2
OQPSK 1/2	IESS-309	219,201	4, 8, 16	64	8448	74.38	9818.173
OQPSK 3/4	None	Off	N/A	64	20000	42.666	30000
OQPSK 3/4	None	219,201	4, 8, 16	64	41301.369	46.487	29999.999
OQPSK 3/4	IESS-309	Off	N/A	64	8448	45.511	6007.467
OQPSK 3/4	IESS-309	219,201	4, 8, 16	64	8448	49.587	6545.449

Table 3-6. IESS-310 Mode – Extended Rates

Modulation Type	Overhead	R-S Code Word	R-S Depth	Data Rate (kbps)	Symbol Rate (ksps)
8-PSK 2/3	None	219,201	4, 8, 16	256	139.463
8-PSK 2/3	None	219,201	4, 8, 16	51840	28241.194
8-PSK 2/3	IESS-309	219,201	4, 8, 16	256	148.76
8-PSK 2/3	IESS-309	219,201	4, 8, 16	8448	4909.087
8-PSK 2/3	IESS-308	219,201	4, 8, 16	1544	937.134
8-PSK 2/3	IESS-308	219,201	4, 8, 16	2048	1211.701
8-PSK 2/3	IESS-308	219,201	4, 8, 16	6312	3534.627
8-PSK 2/3	IESS-308	219,201	4, 8, 16	8448	4698.269
8-PSK 2/3	IESS-308	219,201	4, 8, 16	32064	17563.701
8-PSK 2/3	IESS-308	219,201	4, 8, 16	34368	18818.866
8-PSK 2/3	IESS-308	219,201	4, 8, 16	44736	24467.104

Table 3-7. Turbo Code Mode

Modulation Type	Data Rate (kbps)		Symbol Rate (ksps)	
	Min	Max	Min	Max
BPSK 21/44	64	14318	134.095	29999.999
BPSK 5/16	64	9375	204.8	30000
QPSK 17/18	64	51840	33.882	27444.705
QPSK 21/44	64	28636.363	67.047	29999.999
QPSK 3/4	64	45000	42.666	30000
QPSK 7/8	64	51840	36.571	29622.857
OQPSK 17/18	64	51840	33.882	27444.705
OQPSK 21/44	64	28636.363	67.047	29999.999
OQPSK 3/4	64	45000	42.666	30000
OQPSK 7/8	64	51840	36.571	29622.857
8-PSK 17/18	256	51840	93.353	18296.47
8-PSK 3/4	256	51840	113.777	23040
8-PSK 7/8	256	51840	97.523	19748.571
16-QAM 3/4	256	51840	85.333	17280
16-QAM 7/8	256	51840	73.143	14811.428

Table 3-8. 16-QAM Mode

Modulation Type	R-S Code Word	R-S Depth	Data Rate (kbps)		Symbol Rate (ksps)	
16-QAM 3/4	None	None	256	51840	85.333	17280
16-QAM 3/4	219,201	4, 8, 16	256	51840	92.975	18827.462
16-QAM 3/4	208,192	4, 8, 16	256	51840	92.889	18810
16-QAM 7/8	None	None	256	51840	73.143	14811.428
16-QAM 7/8	219,201	4, 8, 16	256	51840	79.692	16137.825
16-QAM 7/8	208,192	4, 8, 16	256	51840	79.619	16122.857

Note: 16-QAM 3/4 requires Reed-Solomon to be on in order to automatically resolve
data ambiguities.

3.2   Clocking Options

Clocking of the data from the terrestrial equipment to the satellite (and vice versa) will depend on the application. This section describes the most common options and recommended configurations.

SCT (INTERNAL) clock no longer applies when the modem has loop timing on. The TX clock source is now recovered from the RX satellite data. This recovered clock is put out on the ST line and is used to clock the terrestrial equipment. The transmit terrestrial clock is now essentially the same as the RX satellite clock, except that it has been buffered by the terrestrial equipment.

Select **TX TERRESTRIAL** for the TX clock source when in loop timing, if the user equipment is being slaved off the modem.

3.2.1 IDR/IBS G.703 Master/Master

Use this application when both earth stations have high stability clocks and the received data is to be clocked to the local network. Refer to Figure 3-1for:

- Clocking block diagram
- Transmit clock options
- Buffer clock options

The disadvantage of the master/master application is that the receive data will slip, as the clocks will not be synchronized. If the buffer is properly set up, the slips will be an exact frame length, causing minimum loss of data. By using very high stability clocks, the expected time between slips can be several days.

Loss of the buffer clock will mean the buffer will not be emptied and data will not be available. The buffer clock will normally revert to the low stability internal reference automatically.

3.2.2 IDR/IBS G.703 Master/Slave

Use this application when the far end earth station does not have local access to a high stability reference clock, or when it is not required to synchronize with a local clock. Refer to Figure 3-2 for:

- Clocking block diagram
- Transmit clock options
- Buffer clock options for using external loop timing

Modem loop timing does not apply for G.703 operation. The terrestrial equipment must select loop timing to recover the clock off the receive data and use that recovered clock for the transmit data.

The disadvantage of the master/slave application is that the signal received at the slave station is subject to Doppler shift. The length of the buffer at the master end will need to be twice the length that is normally required, compensating for the Doppler shift on the outward and return paths.
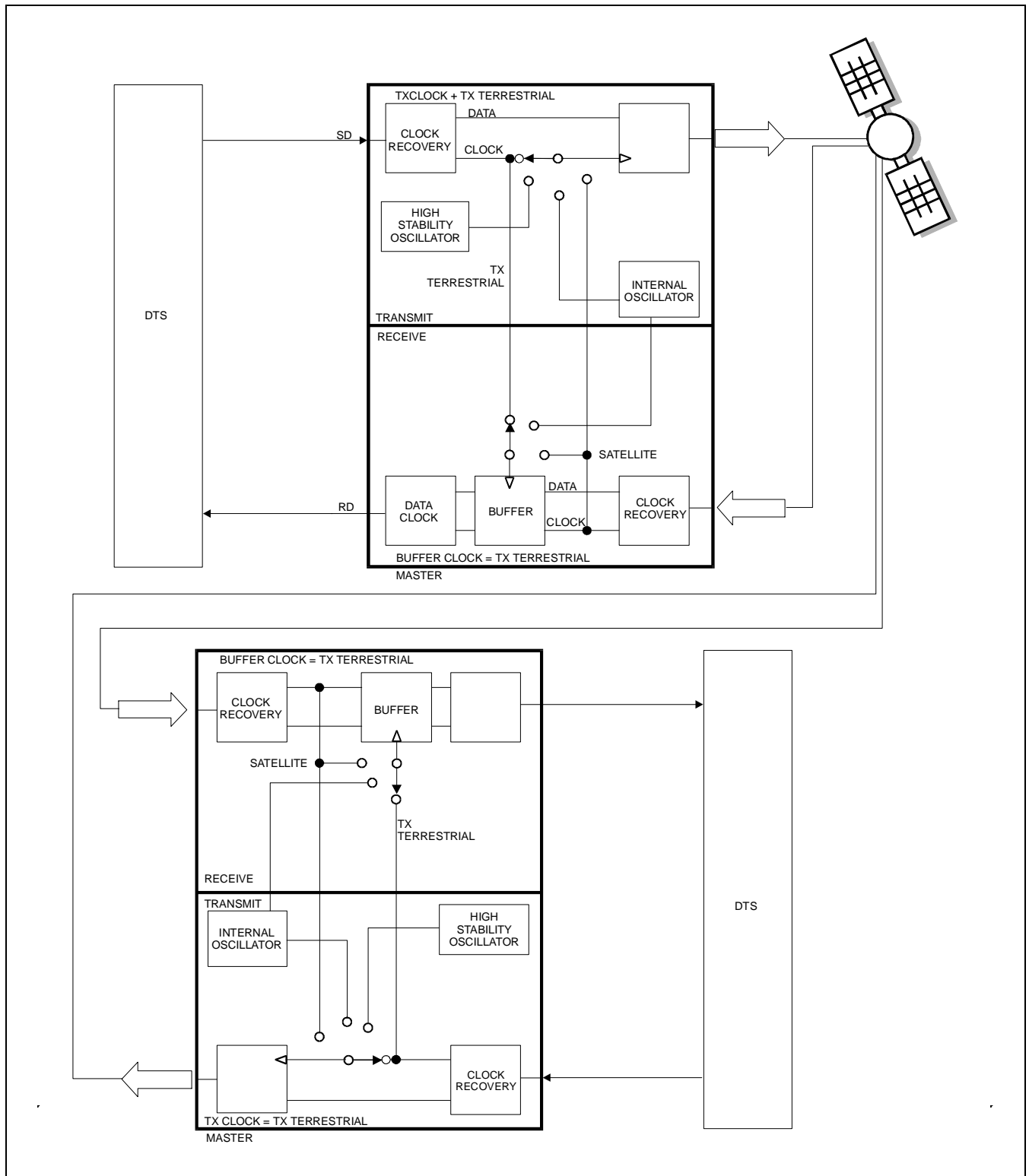
Figure 3-1. IDR/IBS G.703 Master/Master Clocking Diagram
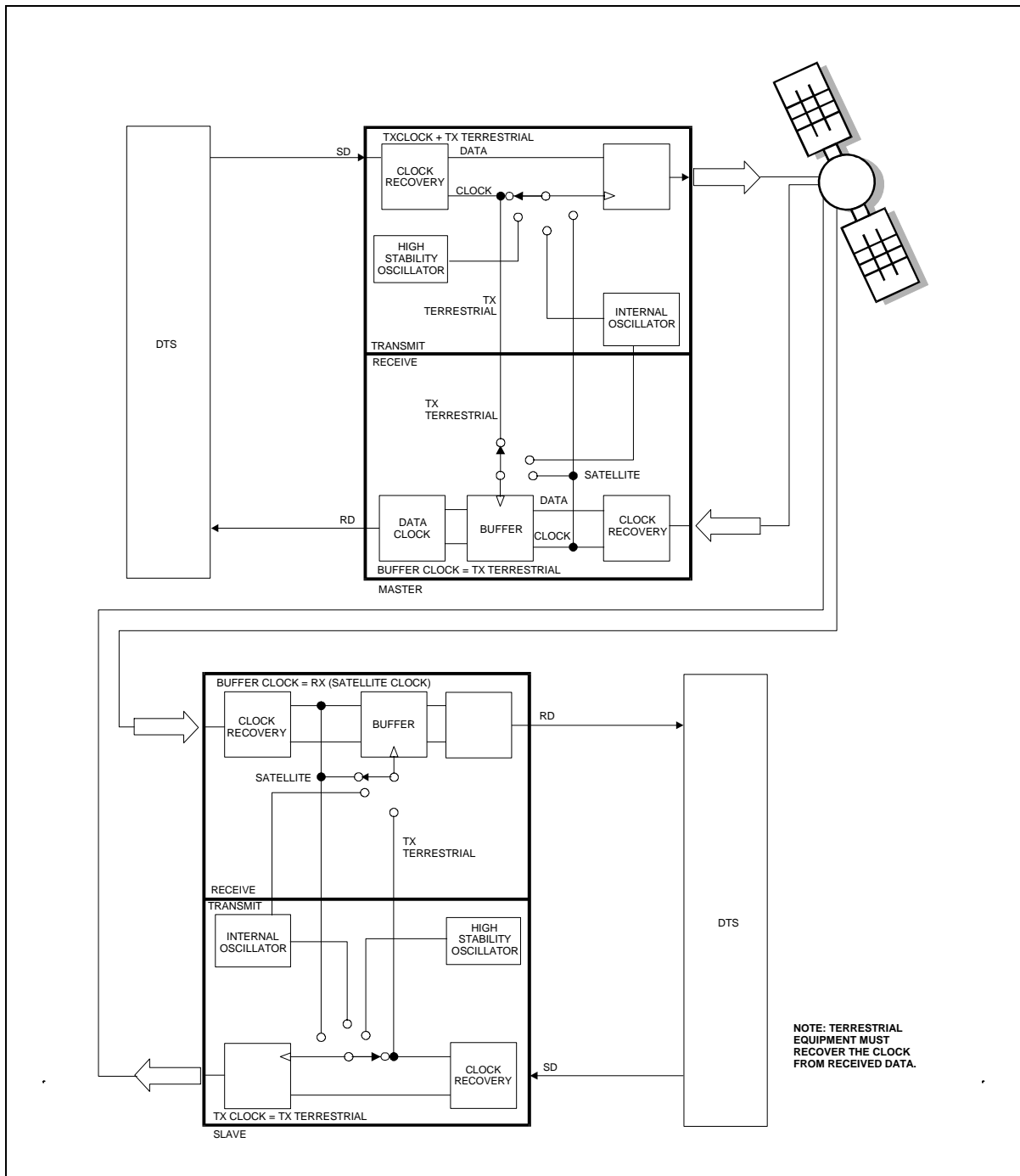
Figure 3-2. IDR/IBS G.703 Master/Slave Clocking Diagram

3.3   Buffering

The purpose of a receive buffer is two reasons:

- Plesiochronous buffering of two dissimilar clock frequencies (normally the far end transmit clock verses the local network clock). The clocks may be very close in frequency to each other and will normally slip at a constant rate. Figure 3-3 shows plesiochronous operation for dissimilar clocks. If incoming traffic is too fast, an occasional bit will be lost. If incoming traffic is too slow, an occasional bit will be repeated.
- Doppler buffer of the signal of the satellite. The Doppler shift results from the "figure 8" (Figure 3-4) station keeping movement performed by the satellite in space over a period of one day. Doppler shift should not result in a clock slip, as the buffer will constantly fill and empty.

If the two earth stations are configured as master/slave, then the buffer need only be configured for Doppler operation. The buffer will then have sufficient capacity for the Doppler shift on the outward and return paths.

A buffer set up for Doppler operation only, will typically require less depth than one intended for both Doppler and plesiochronous operation.

Figure 3-3. Clock Slip

SATELLITE MOTION AND ORBITAL INCLINATION

N

GEO-SYNCHRONOUS
INCLINED ORBIT

GEO-SYNCHRONOUS
EQUATORIAL ORBIT

S

A

SATELLITE
NOMINAL
POSITION

A SATELLITE IS MAINTAINED AT AN
ASSIGNED GEOSTATIONARY
LOCATION THROUGH THE USE OF
GROUND COMMAND ADJUSTMENTS
TO ITS N/S AND E/W LOCATION. THIS
PROCESS, KNOWN AS SATELLITE
STATION-KEEPING, IS USED TO KEEP
THE SATELLITE DRIFT WITHIN
CERTAIN BOUNDARIES.

AS STATION-KEEPING FUEL
BECOMES EXHAUSTED, THE N/S
STATION-KEEPING IS LIMITED
TO PRODUCE A MORE INCLINED
ORBIT, THUS PROLONGING THE
LIFE OF THE SATELLITE.

N

A

C

B

S

SATELLITE
N/S
MOTION

THE N/S MOTION CHANGES THE
PATH FROM THE SATELLITE TO THE
EARTH, RESULTING IN FREQUENCY
CHANGES KNOWN AS THE DOPPLER
EFFECT.

Figure 3-4. Doppler Shift

3.3.1 Buffer Size

The depth of the receive buffer will depend on four parameters:

- Doppler shift caused by satellite
- Stability of each clock (plesiochronous/Doppler operation)
- Frame/Multiframe length of multiplexed data format
- Allowable time between clock slips

3.4 Doppler

A geostationary satellite should be positioned directly over the equator and orbit with duration of 24 hours. In practice, the exact inclination of the satellite (relative to the equator) is influenced by the earth, moon, and sun's gravity, as well as solar wind. Station keeping motors are required to maintain the orbital position.

When viewed from the earth, the satellite appears to prescribe and ellipse in space, degrading to a "figure 8" as the angle of inclination increases.

The orbit of the satellite can result in a peak-to-peak altitude variation of $\pm 2\%$ (85 km), while the station keeping of a newly launched satellite will typically be $\pm 0.1°$ (150 km). The total effect will be 172 km relative to the nominal 42,164 km radius.

Depending upon the location of the earth station relative to the satellite, the variation in propagation delay will typically be 1.15 ms (up to satellite and back down), therefore a buffer depth of 2 ms is sufficient to cope with most commercial satellites.

Since station keeping involves using fuel in the motors, the "lifetime" of the satellite can be extended by allowing the satellite to drift into a wider "figure 8" and using the motor less often.

The older satellites will be found in a more inclined orbit with the station keeping varying in latitude by as much as $\pm 4°$. The total effect of the inclined orbit may result in a typical variation in path delay of 35 ms.

3.5   Plesiochronous

The stability of station reference clocks is normally 1×10^{-12} (derived from a cesium standard). While the stability is exceptionally high, the two clocks are not in synchronization with each other and will eventually pass by each other.

The clock used for the transmit signal is passed over the satellite, but will not be used at the receive earth station where a national network derives its time locally. A buffer will fill up with data using the clock from the satellite and will empty using the local clock. The object of the buffer is to ensure that the buffer overflows or underflows at regular, determinable intervals (typically every 40 days).

The buffer depth required (from center to end) would be:

- Minimum slip period (seconds) ∗ [stability of far end (transmit) clock + stability of local clock]

For example:

Far end (transmit) clock stability	1×10^{-9}
Local (buffer) clock	1×10^{-11}
Minimum clock slip	40 days

Buffer Depth = (40 x 24 x 60 x 60) x (1×10^{-9} + 1×10^{-11}) = 3.49 ms

Because the buffer will either fill or empty (depending on the frequency relationship of the two clocks), the total buffer depth will be 2 x 3.49 ms = 6.98 ms.

3.6   Frame/Multiframe Length

The depth of the receive buffer required is applicable to all unframed data.

When the data is framed (such as 2048 kbps G732 or 1544 kbps G733), it is desirable to provide slips in predefined locations. The advantage of organized slip locations (in relation to the frame) is that multiplexing equipment does not lose sync and outages on any channel are kept to a minimum.

A 2048 kbps frame structure commonly used is G732. This has a frame length of 256 bits with 16 frames per multiframe (4096 bits total, or 2 ms).

3.6.1 Multiples of the Frame Length

If this setting is set to NONE, the user can choose any buffer depth.

3.6.2 Total Buffer Length

T1 and E1 framing structure under G.704 are available. When this is selected, the buffer length is restricted to the size of the buffer. Using the examples from the three previous sections, the total buffer depth (end to end) will be:

> Doppler + Plesiochronous (rounded up to the nearest multiframe)
> 1.15 ms + 6.98 ms = 8.13 ms

If the frame length is 2 ms, then the nearest multiframe will be 10 ms, or 20,480 bits.

3.6.3 Converting Between Bits and Seconds

Bits to Seconds	1/Data Rate x Bits = Seconds.
Seconds to Bits	Data Rate x Seconds = Bit.

Notes:

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Chapter 4. FRONT PANEL OPERATION

This chapter describes the front panel operation of the modem, including the menus and their explanations, and clocking information. For information about remote control operation, refer to Appendix B.

4.1   Front Panel

The modem front panel (Figure 4-1) enables the user to control modem configuration parameters and display the modem status.

Figure 4-1. Modem Front Panel

The front panel features include:

- 40-character, 2-line LCD display
- 6-button keypad for local control
- 12-button array for manual data entry
- 8 LEDs to provide overall status at a glance
- On/Off Power switch
- USB Port

All functions are accessible at the front panel by entering one of six predefined Function Select categories or levels:

- Configuration
- Monitor
- Test
- Save/Load
- Utility

4.1.1 LED Indicators

The eight LEDs on the front panel indicate:

- General modem summary fault information
- Status
- Alarms

The indicators are defined as follows:

LED	Color	Condition
Status		
Unit Status	Green	No Unit Faults or Stored Faults
	Red	A Unit Fault exists
	Blinking	There are Stored Faults.
Tx Status	Green	No Tx Traffic Faults or Alarms exists
	Orange	A Tx Traffic Alarm exists
	Red	A Traffic Fault exists
Rx Status	Green	No Rx Traffic Faults or Alarms exists
	Orange	A Rx Traffic Alarm exists
	Red	A Rx Fault exists
Tx On	Green	Transmitter is currently on. This indicator reflects the actual condition of the transmitter, as opposed to the programmed condition.
	Off	Transmitter is currently OFF.
Alarms		
IF Lock	Green	Demod has constellation lock.
	Off	No constellation lock.
Data Lock	Green	Decoder is locked.
	Off	Decoder is not locked.
Remote	Green	The Unit is in Remote Communication Mode.
	Off	The Unit is in Local Mode – remote monitoring is possible, but no remote control
Test Mode	Orange	A Test Mode is selected (Example: IF Loopback)
	Off	No test mode is selected.

4.1.2 Front Panel Keypad

The front panel keypad controls the local operation of the modem. The keypad consists of 18 keys. Each key provides one or more logical functions.
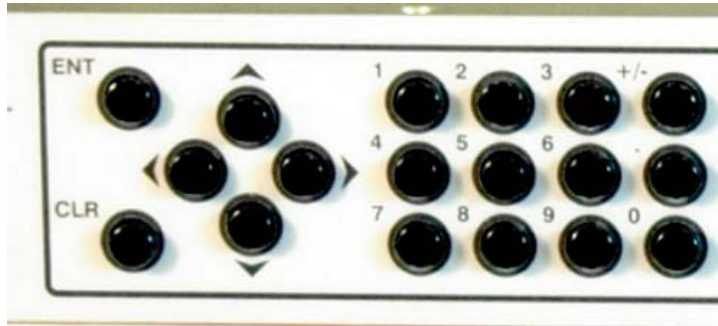
[ENTER]	This key is used to select a displayed function, or to execute a modem configuration change.
[CLEAR]	This key is used to back out of a selection, or to cancel a configuration change, which has not been executed using [ENTER]. Pressing [CLEAR] generally returns the display to the previous selection.
◄ and ►	These keys are used to move to the next selection, or to move the cursor for certain functions.
▲ and ▼	These keys are used primarily to change configuration data (numbers), but are also used at times to move from one section to another.
Numbers	These buttons are used to enter a numerical value manually.
+/-	The +/- buttons allows the user to change signs.

> **IMPORTANT**
>
> ***The keypad has an auto-repeat feature. If a key is held down for more than 3 second, the key action will repeat, automatically, at the rate of 7 keystrokes per second.***

Figure 4-2. Keypad

The modem responds by beeping whenever a key is pressed:

- A single-beep indicates a valid entry and the appropriate action was taken.

- A double-beep indicates an invalid entry or a parameter is not available for operation.

4.1.3 Menu Matrix

Select:			
Configuration 4.3.1)	Transmit	(4.3.1.1)	Mod, DataRate, Overhead, Frequency Power, Clocking,Misc
	Receive	(4.3.1.2	Demod, DataRate, Overhead, Frequency, Acquisition, Buffer,Misc
	Mod	(4.3.1.3)	Mode, FreqBand, Interface
	AUPC	(4.3.1.4)	Local, Enable, Power Settings Target Settings, Carrier Loss Action
	Ref	(4.3.1.5)	Internal, Ext-1 MHz, Ext-5 MHz, Ext-10 Mhz
	Mask	(4.3.1.6)	TxData, RxData, Eb/No, Threshold
	Reset	(4.3.1.7)	
	Remote	(4.3.1.8)	Local, Remote
Monitor (4.3.2)	Alarms	(4.3.2.1)	
	Event-Log	(4.3.2.2)	View, Clear-All
	Rx-Params	(4.3.2.3)	
	Statistics	(4.3.2.4)	View, Clear-All, Configuration
	Gigabit IF Statistics	(4.3.2.5)	
Test (4.3.3)			
Save/Load (4.3.4)	Save		
	Load		
Utility 4.3.4)	RT-CLK		
	RefAdjust		
	ID		
	Display		
	Cal		
	Agc		
	AudibleAlarm		
	Firmware	(4.3.4.1)	Information, Select
	FAST	(4.3.4.2)	

Note: Paragraph numbers are in parenthesizes.

4.2   Opening Screen

This screen is displayed when power switch is in the On position:

```
 Comtech SLM-5650 Modem    Status:       GO
Firmware Version x.x.x     Mode:      TURBO
```

The bottom line displays the internal software version and the selected mode of operation. Press [ENT] to go to the Main Menu screen.

> **IMPORTANT**
>
> *Go to CONFIG: MODE and set the MODEM type, the FREQBAND, and the INTERFACE type prior to preceding with the rest of the modem configuration.*

4.3   Main Menu

```
SELECT: Configure  Monitor   Test
        Save/Load Util
```

The following selections are available:

Configure	Permits the user to fully configure the modem.
Monitor	Permits the user to monitor the alarm status of the unit, to view the log of stored events, and to display the Receive Parameters screen and clear all stored faults.
Test	Permits the user to configure the modem into one of several Test modes.
Save/Load	Permits the user to save and retrieve up to 10 different modem configurations.
Util	Permits the user to perform miscellaneous functions, such as setting the Real-Time Clock, adjusting the display brightness, etc.

4.3.1 Select: Config

```
CONFIG:   Transmit   Receive   Mode   AUPC
          Ref   Mask   Reset   Remote (◄ ►E)
```

The following choices are presented:

Transmit	Permits the user to configure the Tx parameters.
Receive	Permits the user to configure the Rx parameters.
Mode	Permits the user to configure the modem operating modes.
AUPC	Permits the user to configure the AUPC parameters. This menu only appears if the modem type has been set to AUPC.
Ref	Permits the user to configure the modem reference.
Mask	Permits the user to mask selected alarms.
Reset	Permits the user to reset the modem to a default status.
Remote	Permits the user to define whether the unit is being controlled locally or remotely as well as the communication parameters. (See Note.)

IMPORTANT

The modem may be monitored over the remote control interface at any time. When in Local mode, however, configuration parameters may only be changed through the front panel.

4.3.1.1   Select: CONFIG: Transmit

```
Tx: Mod DataRate Overhead Frequency
    Power Clocking Misc            (◄ ►E)
```

Mod	Permits the user to select: FEC, Type, Rate, RS, Diff, and Scrambler.
DataRate	Permits the user to enter a selected data rate and view the symbol rate. (See Chapter 3.)
Overhead	Permits the user to select the overhead type, view the overhead rate, select the Reed Solomon Code Word, and depth.
Frequency	Permits the user to select the desired frequency and spectral inversion.
Power	Permits the user to select desired output power level and state of the output.
Clocking	Permits the user to select the transmit clock source and SCT reference.
Misc	Permits the user to select CLK/DataPhase and BPSK Bit Ordering.

Select: CONFIG: Transmit: Mod

```
Mod: FEC:VIT   Type:QPSK  Rate:1/2
RS:Off  Diff:On  Scram:OM-73      (◄ ►E)
```

Select the **Mod** type using the ◄ ► arrow keys to scroll through all the choices, as follows. The user should then press [**E**].

FEC	**(Viterbi** or **None are standard), (TURBO optional)** Viterbi is a K=7 convolutional encoder. None means Uncoded. Turbo means Turbo Product Code, which is a block code. Trellis operation is supported in IESS-310 mode and MIL-STD-188-165A mode, which for the encoder is just a specific mapping of the constellation. Trellis is not a displayed choice.
Type (Modulation)	**(BPSK**, **QPSK**, **OQPSK standard), (8PSK, or 16QAM optional)** BPSK stands for Bi Phase Shift Keying. QPSK stands for Quadrature Phase Shift Keying. OQPSK stands for Offset Quadrature Phase Shift Keying. 8PSK stands for 8 Phase Shift Keying. 16QAM stands for 16 Quadrature Amplitude Modulation.
Rate	Viterbi: 1/2, 2/3, 3/4, 5/6, or 7/8 Uncoded: 1/1 Turbo: 5/16, 21/44, 3/4, 7/8, or 17/18
RS	On or Off (Reed Solomon Encoder)
Diff	On or Off (Differential Encoder)
Scram:	V.35, M-V.35, IBS, TURBO, OM73, Synch, or Off (Scrambling is for energy dispersal)
V.35	ITU standard
M-V.35	EF Data Closed Network with Reed Solomon compatible (modified V.35)
IBS	Used for IESS-309 and AUPC operation
Turbo	Synchronous scrambler synchronized to the Turbo block
OM73	Linkabit OM-73 modem compatibility mode
Synch	Synchronous scrambler synchronized to the Reed-Solomon.

IMPORTANT

When changing Modulation type the data rate must be set to a rate supported by the modulation type or the change to the modulation type will not be allowed. Some choices will only be visible if the modem is set to a compatible mode or if an option is installed or enabled.

Select: CONFIG: Transmit: DataRate

```
Tx Data Rate:      020000.000 kbps
    Sym Rate:      0266666.666 ksps (◄ ► ▼ ▲ E)
```

The user can enter the desired data rate in kilobits using step 1 or step 2 as follows:

1. Use the number keypad and enter the desired data rate (See Chapter 3).
2. Use the ◄ ► ▼ ▲ arrow keys to scroll up and down to select the desired data rate. When scrolling data rate, the symbol rate will automatically be recalculated and displayed.

IMPORTANT

When entering the data rate, the following interactions need to be taken into account. If the modulation type selected is 8-PSK or 16-QAM the minimum data rate allowed is 256 kbps. When changing certain parameters like modem type, the data rate will default to 64 kbps or 256 kbps. The calculated symbol rate is displayed for the user. This is helpful for determining the occupied bandwidth required for the selected modulation type, code rate and overhead.

Select: CONFIG: Transmit: Overhead

```
Tx:   Overhead:None           Rate: N/A
      RS-CW:N/A               Depth:N/A (◄ ► E)
```

Select the desired **Overhead**, **Rate**, **RS-CW**, and **Depth** and then press [**E**].

Overhead	(IESS-308, IESS-309 are standard), (AUPC is optional)
Rate	96 kbps (IESS-308), 1/15 (IESS-309 or AUPC), N/A (None)
RS-CW	126/112, 194/178, 208/192, 219/201, 220/200, 225/205, (Reed Solomon Code Word, N/K)
Depth	4, 8 or 16 (Interleaving depth)

IMPORTANT

Some selections will only be visible if the modem is set to a compatible mode or if an option is installed or enabled.

Select: CONFIG: Transmit: Frequency

```
Tx Frequency:   1955.0000 MHz
     Spectrum:  Normal               (◄ ► ▼ ▲ E)
```

Edit the **Tx Frequency**, using either step 1 or 2:
1. Key in the desired frequency using the numbered keypad.
2. Select the digit to be edited, using the ◄ ► arrow keys. The value of the digit is then changed using the ▲ ▼ arrow keys. The user should then press [**E**]

7/140 MHz	52-88, 104-176 MHz (in 100 Hz steps)
L-Band	950-2000 MHz (in 100 Hz steps)
Spectrum	**Normal** or **Invert**, (used to counteract frequency converters that invert the spectrum)

> **IMPORTANT**
>
> *When entering an IF frequency, the M&C will check the occupied bandwidth calculated from the data rate, modulation type, code rate and overhead and will not allow an IF frequency to be entered if the occupied bandwidth falls outside of the minimum or maximum IF frequencies.*

Select: CONFIG: Transmit: Power

```
Tx Power:   State:On   Level:-20.0
            Control:  Normal      (◄ ► ▼ ▲ E)
```

State	Permits the user to select On or Off.
Level	Permits the user to edit the Power Level from –40 dBm to +10 dBm in 0.1 dB steps by either:
	1. Key in the desired number using the keypad.
	2. Select the digit to be edited using the ◄ ► arrow keys. The value of the digit is then changed using the ▼ ▲ arrow keys.
	3. The user should then press [**E**].
Control	Permits the user to select **Normal** or **RTS**. RTS is an interface signaling control. It stands for Request to Send. If enabled RTS can be used to control the output state of the modulator. Only available when using either the EIA-530 or HSSI interface.

Select: CONFIG: Transmit: Clocking

```
Tx Clocking:   CLK Source: SCT       (◄ ►E)
               SCT Ref:    Reference
```

Select **Clk Source** or **SCT Ref**, then press [**E**].

Clk Source	**SCT** or **Tx-Terr** SCT stands for Send Clock Timing or also is referred to as internal and is provided as an output to provide a clock reference for the user. Tx-Terr stands for the transmit clock input on the selected data interface.
SCT Ref	**Reference**, **DataSrcSync**, or **Looptiming** If reference is selected SCT will be generated from the modem's 10 MHz reference (this could be derived from and external reference if selected. DataSRCSync stands for Data Source Synchronization. This is an operational mode where no clock is provided on the interface and a clock is generated such that it is phase locked to the incoming data stream. Looptiming is when the clock generated from the received carrier is used as a reference for generating SCT.

Select: CONFIG: Transmit: Misc

```
Tx Misc:  Clk/DataPhase  BitOrdering
                                    (◄ ►E)
```

Select **Clk/DataPhase** or **BitOrdering**, then press [**E**].

ClkPhase	Tx Clock Phase, **Normal** or **Inverted**
DataPhase	Tx Data Phase, **Normal** or **Inverted**
BitOrdering	Tx Bit Ordering (for BPSK compatibility), **Standard** or **Non-Standard**

4.3.1.2   Select: CONFIG: Receive

```
Rx: Demod DataRate Overhead Frequency
    Acquisition Buffer Misc    (◄ ►E)
```

Demod	Permits the user to select FEC, Type, Rate, RS, Diff, and Descrambler.
DataRate	Permits the user to enter a selected data rate. (See Chapter 3.)
Overhead	Permits the user to select the overhead type, view the overhead rate, select the Reed Solomon Code Word, and depth.
Frequency	Permits the user to select desired frequency and spectral inversion.
Acquisition	Permits the user to select acquisition range and reacquisition time period.
Buffer	Permits the user to select buffer reference clock source, recenter, the buffer size, Bit mode or millisecond mode and external Framing for Plesiochronous operation.
Misc	Permits the user to select Clk and Data Phase, BPSK Bit Ordering, and Eb/No Threshold.

Note: Framing is applicable only when using externally framed data, with the following formats:

- T1 or E1 G.704

- T2 G.743, G.704, G.707

- E2 G.742, G.704, G.745

Select: CONFIG: Receive: Demod

```
Demod: FEC:VIT    Type:BPSK   Rate:3/4
RS:N/A   Diff:On   Descram:OM-73        (◄ ►E)
```

Select the **Demod,** T**ype, RS, Diff,** and **Descram**. Use the ◄ ► arrow keys to scroll through all the choices. The user should then press [**E**].

FEC	**(Viterbi** or **None are standard), (TURBO optional)** Viterbi is a K=7 convolutional decoder. None means Uncoded. Turbo means Turbo Product Code, which is a block code. Trellis operation is supported in IESS-310 or MIL-STD-188-165A mode which a different front end is applied the Viterbi decoder. Trellis is not a displayed choice.
Type (Modulation)	**(BPSK**, **QPSK**, **OQPSK standard), (8PSK, or 16QAM optional)** BPSK stands for Bi Phase Shift Keying. QPSK stands for Quadrature Phase Shift Keying. OQPSK stands for Offset Quadrature Phase Shift Keying. 8-PSK stands for 8 Phase Shift Keying. 16-QAM stands for 16 Quadrature Amplitude Modulation.
Rate	Viterbi: 1/2, 2/3, 3/4, 5/6, or 7/8 Uncoded: 1/1 Turbo: 5/16, 21/44, 3/4, 7/8, or 17/18
RS	On or Off (Reed Solomon Decoder)
Diff	On or Off (Differential Decoder)
Descram:	V.35, M-V.35, IBS, TURBO, OM73, Synch, or Off (Descrambling)
V.35	ITU standard
M-V.35	EF Data Closed Network with Reed Solomon compatible (modified V.35)
IBS	Used for IESS-309 operation
Turbo	Synchronous descrambler synchronized to the Turbo block
OM73	OM-73 Linkabit modem compatibility mode
Synch	Synchronous descrambler synchronized to the Reed-Solomon frame.

IMPORTANT

When changing Modulation type the data rate must be set to a rate supported by the modulation type or the change to the modulation type will not be allowed. Some choices will only be visible if the modem is set to a compatible mode or if an option is installed or enabled.

Select: CONFIG: Receive: DataRate

```
Rx Data Rate:     020000.000 kbps
   Sym Rate:      0266666.666 ksps (◄►▼▲E)
```

The user can enter the desired data rate using step 1 or step 2 as follows:

1. Use the number keypad and enter the desired data rate (see Chapter 3).
2. Use the ◄ ► ▼ ▲ arrow keys to scroll up and down to select the desired data rate or symbol rate. When scrolling data rate the symbol rate will be automatically recalculated and displayed.

IMPORTANT

When entering the data rate, the following interactions need to be taken into account. If the modulation type selected is 8-PSK or 16-QAM the minimum data rate allowed is 256 kbps. When changing certain parameters like modem type, the data rate will default to 64 kbps or 256 kbps. The calculated symbol rate is displayed for the user. This is helpful for determining the occupied bandwidth required for the selected modulation type, code rate and overhead.

Select: CONFIG: Receive: Overhead

```
Rx:  Overhead:None      Rate: N/A
     RS-CW:N/A           Depth:N/A (◄►E)
```

Select the desired **Overhead**, **Rate**, **RS-CW**, and **Depth** and then press [**E**].

Overhead	(IESS-308, IESS-309 are standard), (AUPC is optional)
Rate	96 kbps (IESS-308), 1/15 (IESS-309 or AUPC), N/A (none)
RS-CW	126/112, 194/178, 208/192, 219/201, 220/200, 225/205 (Reed Solomon Code Rate, N/K)
Depth	4, 8 or 16 (Deinterleaving depth)

IMPORTANT

Some selections will only be visible if the modem is set to a compatible mode or if an option is installed or enabled.

Select: CONFIG: Receive: Frequency

```
Rx Frequency:   1955.0000 MHz
    Spectrum:   Normal              (◄ ►E)
```

Edit the **Rx Frequency**, using either step 1 or 2:
1. Key in the desired frequency using the numbered keypad.
2. Select the digit to be edited, using the ◄ ► arrow keys. The value of the digit is then changed using the ▲ ▼ arrow keys. The user should then press [**E**]

7/140 MHz	52-88, 104-176 MHz (in 100 Hz steps)
L-Band	950-2000 MHz (in 100 Hz steps)
Spectrum	**Normal** or **Invert**, (used to counteract frequency converters that invert the spectrum)

IMPORTANT

When entering an IF frequency, the M&C will check the occupied bandwidth calculated from the data rate, modulation type, code rate and overhead, and will not allow an IF frequency to be entered if the occupied bandwidth falls outside of the minimum or maximum IF frequencies.

Select: CONFIG: Receive: Acquisition

```
Acquisition:   Range: 0001.000 KHz
               Reacq: 000 Seconds (◄ ►▼▲E)
```

Edit the value as described in step 1 or 2 as follows:

1. Key in the desired frequency range using the numbered keypad.
2. Select the digit to be edited, using the ◄ ► arrow keys. The value of the digit is then changed using the ▲ ▼ arrow keys. The user should then press [**ENTER**].

Range	0 to 60 kHz in 1 Hz steps, Demodulator Acquisition range
Reacq	0 to 999 seconds, Hold off time before the demodulator reverts to normal acquisition. During the holdoff the demodulator will stay centered on the last known frequency position of the carrier for faster reacquisition.

Select: CONFIG: Receive: Buffer

```
Buffer:  Src:RX-Sat Center: Y/N
 Size:00001024  Mode:Bits  Framing (◄►E)
```

Src	Rx-Sat, Int, or Tx-Terr. Rx-Sat is the recovered clock from the received carrier. Int is a clock synthesized from the modems reference (internal or external). Tx-Terr is the transmit clock supplied by the user.
Center	Yes or No, the buffer is automatically centered when the demodulator locks. By selecting center, the buffer can be manually centered.
Size	If in Bits, the minimum size is 128 to a maximum of 4,194,304 in 16 bit steps. If in milliseconds (mSec), the minimum size is 2 to a maximum of 60 in 1 mSec steps.
Mode	Bits or mSec, buffer size format.
Framing:	If selected this allows the buffer to operate in a plesiochronous mode when running externally framed data. If buffer mode is set to mSec and Rx data rate is 1544 kbps (T1), 2048 (E1), 6312 kbps (T2), or 8448 kbps (E2) then the selected framing card will be used to calculate the required buffer size so that the buffer will slip properly.
T1	G704 or None
E1	G704 or None
T2	G704, G743, G747, or None
E2	G704, G742, G745, or None

> **IMPORTANT**
> *While the framing selections show up in the menus regardless of which interface is plugged in, they will only have effect if a G.703 interface is plugged into the modem.*

Select: CONFIG: Receive: Misc

```
Rx Misc:  Clk/DataPhase  BitOrdering
          Eb/No Threshold          (◄►E)
```

Select **Clk/DataPhase, BitOrdering or Eb/No Threshold**, then press [**E**].

ClkPhase	Rx Clock Phase, Normal or Inverted
DataPhase	Rx Data Phase, Normal or Inverted
BitOrdering	Rx Bit Ordering (for BPSK compatibility), Standard or Non-Standard
Eb/No Threshold	0.1 to 20 dB in 0.1 dB steps, this sets an Eb/No threshold such that when the received carrier Eb/No is less than the set value, the Rx threshold alarm is set.

4.3.1.3   Select: CONFIG: Mode

```
Mode: Modem:TURBO  FreqBand:L-Band
      Interface:EIA-530              (◄ ►E)
```

Modem:	
OM-73	This selects Linkabit OM-73 modem compatibility mode.
MIL-165A	This selects functionality defined by MIL-STD-188-165A.
IESS-308	This selects functionality defined by IESS-308, the Intelsat Intermediate Data Rate standard.
IESS-309	This selects functionality defined by IESS-309, the Intelsat Business Services standard.
IESS-310	This selects functionality defined by IESS-310, the Intelsat 8-PSK Intermediate Data Rate standard.
TURBO	This selects functionality defined by IESS-315 plus Comtech EF Data Turbo mode interoperability.
16-QAM	This mode allows 16-QAM to be selected as a modulation type.
AUPC	This mode allows Automatic Uplink Power Control to be used.
Frequency Band	Permits the user to select:
	70/140 MHz, (52 – 88 MHz, 104 – 176 MHz)
	L-Band, (950 – 2000 MHz)
Interface	Permits the user to select:
	EIA-530, (native interface, standard equipment)
	HSSI, (native interface, standard equipment)
	GigaBit Ethernet, (optional data interface)

IMPORTANT

When selecting an IF frequency band both transmit and receive operate in the selected band. Operation of transmit in one IF frequency band and the receive in the other IF frequency band is not permitted. When selecting a data interface type, a native interface can be selected even if an optional interface is installed, but an optional interface can only be selected if it is installed. Both transmit and receive must use the selected interface type. Transmitting using one interface type and receiving using another interface type is not permitted.

4.3.1.4   Select: Configuration: AUPC: Local

```
Local AUPC: Enable: Off Power Settings
Target Setting  Carrier Loss Action (◄ ▶E)
```

Select either **Enable**, **Power Settings**, **Target Settings**, or **Power Loss Action**, then press (**E**).

Enable	On or Off: Allows the user to enable AUPC on the local modem.
Power Settings	Nominal Output Power: (-40 to +10 dB) Min Output Power: (-40 to +10 dB) Max Output Power: (-40 to +10 dB)

Target Settings	Eb/No: allows the user to set the Target Eb/No for AUPC
	          (Range: 3.2 to 16.0 dB)
	Rate of Change: allows the user to set the maximum tracking rate
	          (Range: 0.5 to 6.0 dB per minute in 0.5 dB increments)

Carrier Loss Action	Local allows the user to set the action of the local modem when the remote modem loses carrier detect (Hold, Nominal, Maximum).

Select: Configuration: AUPC: Remote

```
Remote AUPC: Enable: Off BasebandL: Off
Tx Pattern: Off BER: Loss          (◄ ▶E)
```

Select either **Enable, BasebandL, or Tx Pattern,** then press (**E**).

Enable	Allows the user to view or modify the status of the remote modem's AUPC Enable (On, Off).
BasebandL	Allows the user to view or modify the status of the remote modem's I/O Loopback #1 setting (On, Off).
Tx Pattern	Allows the user to view or modify the status of the remote modem's Tx pattern substitution (On, Off). In order to maintain compatibility with older Comtech EF Data modems, only 2047 pattern substitution is supported.
BER	Allows the user to monitor BER of the remote modem. The remote modem shall have Tx Pattern set to On and the local modem shall be transmitting a 2047 pattern.

4.3.1.5   Select: CONFIG: Ref

```
Reference: Internal Ext-1Mhz
           Ext-5Mhz Ext-10Mhz            (◄ ►E)
```

Select **Internal, Ext-1Mhz, Ext-5Mhz or Ext-1Mhz**, then press [**E**].

Internal	Permits the user to select : Internal high stability ovenized 10 MHz oscillator
Ext-1MHz	Permits the user to select: An external 1 MHz reference, (accepts sine wave or square wave and locks the internal reference to the 1 MHz)
Ext-5MHz	Permits the user to select: An external 5 MHz reference, (accepts sine wave or squarewave and locks the internal reference to the 5 MHz)
Ext-10MHz	Permits the user to select: An external 10 MHz reference, (accepts sinewave or squarewave and locks the internal reference to the 10 MHz)

4.3.1.6   Select: CONFIG: Mask

```
Mask: TxData   RxData   Eb/No   Threshold
                                    (◄ ►E)
```

TxData	Permits the user to select : Masked, Activity, or AIS, (this alarm monitors data activity on the transmit data interface).
RxData	Permits the user to select : Masked, Activity, or AIS, (this alarm monitors the received data activity).
Eb/No Threshold	Permits the user to select : Masked or Active, (this alarm monitors the receive Eb/No of the demodulator and compares it to the Eb/No threshold value).

IMPORTANT

When selecting masked for a given alarm, if the condition occurs the alarm will not be set. Activity or active means the alarm is enabled. AIS stands for alarm indication signaling. This will put out all ones allowing the connected equipment to recognize that there is an alarm condition.

4.3.1.7   Select: CONFIG: Reset

```
Are you sure that you want to default the
modem configuration?  No  Yes        (◄ ►E)
```

IMPORTANT | *When selecting RESET all parameters in the modem get reset to the default settings. This includes the real time clock and the stored configurations.*

4.3.1.8   Select: CONFIG: Remote

```
Remote Control:  Local
                 Remote              (◄ ►E)
```

Local	Permits the user to select **Local**, which will limit the remote control to only be able to monitor the status of the modem.
Remote	Permits the user to select **Remote,** which will enable remote control. Further selections under remote include, **Serial** or **Ethernet**.

Select: CONFIG: Remote: Remote

```
Remote Control:  Serial
                 Ethernet            (◄ ►E)
```

Select **Serial** or **Ethernet** by using ◄ ►arrow keys, then press [**E**].

Serial	Permits the user to select the interface type either **RS-232, RS-485 2 wire or RS-485 4 wire and the baud rate**.
Ethernet	Permits the user to select **Ethernet**.

Select: CONFIG: Remote: Remote: Serial

If **Serial** was selected:

```
Remote Control:  Interface
                 Baudrate           (◄ ►E)
```

Select: CONFIG: Remote: Remote: Serial: Interface

If **Interface** was selected:

```
M&C Bus Interface:  RS232   RS485-2W
RS485-4W  TTL (Switching)     (◄ ►E)
```

Select **RS232**, **RS485-2W** (2-wire), or **RS485-4W** (4-wire), or TTL (Switching)
using the ◄ ► arrow keys, then press [**E**]. The TTL (Switch) selection enables
interoperation with the CRS-311 (1:1) or CRS-300 (1:N) switch.

```
Local M&C Bus Address:
                0000
```

IMPORTANT

*When selecting RS-232 the local M&C bus address displays, 0000.
Addressing is not supported by RS-232 or TTL (Switch)because they
are not a multi drop communication standards. If RS-485 is selected,
the display will show address 0001. This address can be changed
using the front panel. The most significant digit is for Comtech EF
Data redundancy switches.*

Select: CONFIG: Remote: Remote: Serial: Interface: Baudrate

If **Baudrate** was selected:

```
Local M&C Bus Baud Rate:
           38400 Baud            (▼▲E)
```

IMPORTANT

*The only asynchronous character format supported is 8 bits data, No
parity and 1 stop bit.*

Select: CONFIG: Remote: Remote: Ethernet

If Ethernet was selected:

```
Ethernet Config:  IP Address/Range    MAC
Gateway  SNMP  GigaBit I/F Addr
```

IP Address/Range	Permits the user to select the IP address .
MAC	Displays the modem's MAC address, this is programmed at the factory and is not user changeable. If installed, the Gigabit Ethernet interface's MAC address will also be displayed.
Gateway	The IP Gateway address is the default address that the modem will send all IP responses when the message originated from a source outside the modems local attached network.
SNMP	Permits the user to select and control **Communities** or **Traps**.
GigaBit Interface Address/Range	Permits the user to set the Gigabit Ethernet interface's management IP address and subnet mask (range).

> **!**
> **IMPORTANT**
> *For the address fields the value of the digit is changed using the ▲ ▼ arrow keys. The user should then press [E]*

4.3.2   Select: Monitor

```
Monitor: Alarms   Event-Log   Rx-Params
         Statistics GigaBit I/F Stats
```

Alarms	Permits the user to select and view **Tx, Rx,** or **Unit** alarms.
Event-Log	Permits the user to select **View,** or **clear-all** stored events.
Rx-Params	Permits the user to view **FC, RSL, BERT, Buffer, Eb/No,** or **BER**.
Statistics	Permits the user to select **View**, **Clear-All** or **Config** statistics.
GigaBit I/F	Gigabit Interface link statistics. Permits the user to select **View** or **Clear-All.**

4.3.2.1   Select: Monitor: Alarms

Tx	Permits the user to view transmit alarms.
Mod #1	Modulator symbol clock Phase Lock Loop status.
Mod #2	Modulator RF Synthesizer Phase Lock Loop status.
Mod #3	Modulator IQ activity status.
Mod #4	Modulator Nyquist filter Over range.
Tx Intf #1	Transmit data interface clock Phase Lock Loop status.
Tx Intf #2	Transmit data interface terrestrial clock activity status.
Tx Intf #3	Transmit data interface SCT (send clock timing) Phase Lock Loop status.
Tx Intf #4	Transmit data interface AIS (alarm indication signal) status.
Rx	Permits the user to view receive alarms.
Demod #1	Demodulator carrier Phase Lock Loop status.
Demod #2	Demodulator FEC (forward error correction) lock status.
Demod #3	Demodulator RF Synthesizer Phase Lock Loop status.
Demod #4	Demodulator IQ activity status.
Rx Intf #1	Demultiplexer lock status.
Rx Intf #2	Doppler buffer status.
Rx Intf #3	Doppler buffer fill status.
Rx Intf #4	Doppler buffer overflow status.
Rx Intf #5	Doppler buffer underflow status.
Rx Intf #6	Doppler buffer Phase Lock Loop status.
Rx Intf #7	Doppler buffer reference clock activity status.
Rx Intf #8	Receive data interface AIS (alarm indication signal) status.
Rx Intf #9	Receive Eb/No lower than Eb/No threshold status.
Unit	Permits the user to view unit alarms.
Unit #1	+ 5 volt power supply is out of tolerance.
Unit #2	+ 3.3 volt power supply is out of tolerance.
Unit #3	+ 2.5 volt power supply is out of tolerance.
Unit #4	+ 1.5 volt power supply is out of tolerance.
Unit #5	+ 12 volt power supply is out of tolerance.
Unit #6	- 12 volt power supply is out of tolerance.
Unit #7	+ 18 volt power supply is out of tolerance.
Unit #8	Cooling fan fault.
Unit #9	External reference activity status.
Unit #10	192 MHz clock Phase Lock Loop status.
Unit #11	10 MHz reference Phase Lock Loop status.
Unit #12	M&C FPGA configuration fault.
Unit #13	Modulator FPGA configuration fault.
Unit #14	Demodulator FPGA configuration fault.
Unit #15	Decoder FPGA configuration fault.
Unit #16	Transmit interface FPGA configuration fault.
Unit #17	Receive interface FPGA configuration fault.
Unit #18	FEC #1 FPGA configuration fault.
Unit #19	FEC #2 FPGA configuration fault.
Unit #20	Optional data interface card FPGA configuration fault.
Unit #21	FPGA DCM Phase Lock Loop fault.

Select: Monitor: Alarms: Transmit: Mod 1st Position

If Mod 1st character was selected.

```
Mod:  +---                Mod symbol clk
Intf: ----                  not locked.
```

Select: Monitor: Alarms: Transmit: Intf 1st Position

If Intf 1st character was selected.

```
Mod:  ----                TXIntf data
Intf: +---                  not locked.
```

Select: Monitor: Alarms: Receive: Demod 1st Position

If Demod 1st character is selected.

```
Demod: +---                Demod IF not
Intf: ---------               locked
```

Select: Monitor: Alarms: Receive: Intf 1st Position

If Intf 1st character is selected.

```
Demod: ----                Demux not
Intf: +--------               locked
```

Select: Monitor: Alarms: Unit 1st Position

If Unit 1st character is selected.

```
Unit: +--------------- +5.0V Power is
      -----             out of range.
```

4.3.2.2   Select: Monitor: Event-Log

```
Stored Events: View  Clear-All
                              (◄ ►E)
```

View	Permits the user to view the stored faults. The modem will store up to 255 fault events.
Clear-All	Permits the user to clear all stored faults.

IMPORTANT

To view the details of a stored fault select an event number by pressing enter. Then scroll through the listed faults for a description of the fault. If the faulted listed is power on or power off, nothing will be displayed if that event is selected.

Select: Monitor: Event-Log: View

```
Event 001:003  1:43:02  27/09/05
Mod:  ---- ++ --               (▼▲E)
```

4.3.2.3   Select: Monitor: Rx-Params

```
Fc=+05917  RSL<-60.0 dBm    BERT=N/A
Buf=000%  Eb/No=Loss    BER <1.0E-12 (◄▶E)
```

FC	Permits the user to view the received carrier frequency offset in Hz. The range is the same as the acquisition range of the modem, 60 kHz.
RSL	Permits the user to view the signal level of the received carrier in dBm. The range supported is +15 to –60 dBm.
BERT	Permits the user to view the measured BER. This requires that the modem be set to Test mode for Rx. If a Fireberd is supplying a data pattern, only the Test mode for the Rx needs to be turned on. The Fireberd data pattern and the modems data pattern must match to work properly.
Buf	Permits the user to view the buffer fill status in a percentage format.
Eb/No	Permits the user to view the estimated Eb/No of the received carrier. The range is threshold to 20 dB Eb/No.
BER	Permits the user to view the estimated BER based on the demodulator's measurement of the carrier to noise.

IMPORTANT

The difference between BER and BERT is: BER is estimated in the demodulator, BERT is measured when the test mode is turned on.

4.3.2.4   Select: Monitor: Statistics

```
Link Statistics: View  Clear-All
                 Config        (◄▶E)
```

View	Permits the user to view the stored statistics. The statistics are limited to minimum, average and maximum Eb/No.
Clear-All	Permits the user to clear all stored statistics.
Config	Permits the user to set the interval that the statistics are stored. This ranges from 10 minutes to 90 minutes in 10 minute steps. The function can also be disabled.

4.3.2.5   Select: Monitor: GigaBit I/F Statistics

```
GigaBit Ethernet Card Statistics:
   View  Clear-All
```

View	Permits the user to view the link statiscal counters.
Clear-All	Permits the user to clear or reset the FPGA link error counter.

(!) IMPORTANT   *This menu will not appear unless a GigaBit Ethernet Interface is plugged into the modem.*

4.3.3   Select: Test

```
TEST: Carrier  Loopback  BERT
                           (◄ ►E)
```

Carrier	Permits the user to select carrier test modes, which include, **Normal**, **Tx-CW** or **Tx-1,0**. Normal means, standard modem operation, not a test mode. Tx-CW means a pure carrier, which can be used for frequency and power measurements. Tx-1,0 means that the modulator will produce an offset test carrier (single upper side band suppressed carrier), This test mode allows the user to check for quadrature error in the modulator.
Loopback	Permits the user to select **Normal, IF, I/01, I/02** modes. Normal means, standard modem operation, not a test mode. IF mode means, that the output of the modulator is looped back to the demodulator (inside the modem) to verify transmit and receive configurations match as well as the data inputs and outputs. I/O1 means, baseband loopback which will loop the transmit data (after the interface) back to the receive data path interface. This mode is useful for checking interface cabling and clocking. I/O2 is currently the same as I/O1.
BERT	Permits the user to select **Tx, Pattern, Errins, Reset, Rx. Errs** or **BER**. Tx on/off allows the user to either ignore the Tx data interface or use an internally generated PN pattern, or to function normally. Pattern allows the user to select test data patterns. Error insert allows the user to insert errors in the data stream to verify that the circuit is indeed connected and operational. Reset allows the user to clear the BER and Error displays while restarting the test. Rx on/off allows the user to turn the bit error tester on. This will count any errors in the receive data stream and compare it to a time base. Errors are the absolute count of errors, which is very useful when the error insert mode is on. BER is the measured bit error rate.

4.3.3.1 *Select: Test: BERT*

```
BERT: Tx:Off Pattern:2047  ErrIns  (◄ ►E)
Reset Rx:Off Errs:=0000000 BER:NoSync
```

Tx	Permits the user to turn the transmit test pattern generator **On or Off**.
Pattern	Permits the user to select a number of test data patterns.
Mark	Means, all one's.
Space	Means, all zero's.
1:1	Means, a one followed by a zero and then repeats.
1:3	Means, a one followed by two zero's and then repeats.
2E15-1	A pseudo-random data pattern of $2^{15} - 1$, compatible with standard BERT's.
2E20-1	A pseudo-random data pattern of $2^{20} - 1$, compatible with standard BERT's.
2E23-1	A pseudo-random data pattern of $2^{23} - 1$, compatible with standard BERT's.
MIL188	A modified pseudo-random data pattern of $2^{11} - 1$, compatible with the MIL-188-165 test data pattern requirement of a continuous stream of 50 zero's every 10,000 bits. This pattern has 5 normal 2047 patterns, with the fifth patterns longest string of zero's (11) stretched an additional 39 bits to create a lack of transitions for 50 bits approximately every 10,000 bits.
2047	A pseudo-random data pattern of $2^{11} - 1$, compatible with standard BERT's.
ErrIns	Permits the user to insert a single error in the data stream, by pressing enter.
Reset	Permits the user to restart the BER test and clear the error and BER displays.
Rx	Permits the user to turn on the receive bit error test set.
Errs	Permits the user to view the absolute number of errors counted.
BER	Permits the user to view the bit error rate as measured by the modem.

IMPORTANT

The BER function can work with a firebird supplying the transmit data test pattern, while only turning on the Rx bit error rate tester. The transmit test pattern generator can be turned on at the far end of the link and as long as the test patterns match the Rx BERT can measure the BER of the link. An external bit error test set can be used even when the internal bit error test set is enabled. If AIS is enabled the data will be over written with all one's.

4.3.3   Select: Save/Load

```
Save/Load: Loc:0  Action: View
          Empty                 (◄ ►E)
```

Loc	Permits the user to select the location to either save or load a configuration. There are 10 locations available, 0 – 9.
Action	Permits the user to select either Save or load the selected location. View is the default setting that allows the user to select the location before loading or saving. To save a configuration go through the modems menu's and configure all the necessary parameters. Then select a location, then select save and press enter. To load a saved configuration, select the desired configuration, then select load and press enter.

> ***Resetting the modem will cause all configurations to be cleared!***

4.3.4   Select: Utility

```
UTILITY: RT-Clk RefAdjust ID Display  Cal
     Agc    AudibleAlarm Firmware FAST
```

RT-Clk	Permits the user to select and set the Real-Time Clock. Hours are in 24 hour time format. Date format is day, months and years.
RefAdjust	Permits the user to select and adjust the internal high stability 10 MHz oscillator to counteract aging. The control value is in hex, not decimal and has a range of 000 to FFF. The typical cal point for a modem is nominally around 400.
ID	Permits the user to give the communications link a name. This name can be a combination of alpha and numeric characters up to 24 characters in length. Additional characters supported are: (,), *, +, /, period, comma and space.
Display	Permits the user to adjust the front panel display brightness. Settings are 25%, 50%, 75% or 100%.
Cal	Permits the user to calibrate the L-Band IF board. This calibration is required when increasing the data rate beyond 52 Mbps and is **Not** operational at this time.
Agc	Permits the user to select Minimum and Maximum voltage levels for the external AGC monitor voltage that is available on the AUX connector.
AudibleAlarm	Permits the user to disable or enable the alarm.
Firmware	Permits the user to select which image will be loaded and view information on the Boot ROM, Image#1 or Image#2.
FAST	Permits the user to load FAST codes and view the modem serial number plus the enabled FAST options.

Select: Utility: RT-Clk

```
Edit Real-Time Clock:
15:34:25 27/09/05                    (▼▲◄►E)
```

Select: Utility: RefAdjust

```
Internal 10 MHz Ref Freq
Fine Adjust: 3F3                  (▼▲◄►E)
```

Select: Utility: AGC

```
AgcMan:    Min Value: 00.0 Volts
           Max Value: 10.0 Volts (◄►E)
```

Min Value	Permits the user to specify the voltage to output on the External AGC voltage signal when the demodulator RSL is at it's minimum level.
Max Value	Permits the user to specify the voltage to output when the demodulator RSL is at it's maximum level.

4.3.4.1   Select: Utility: Firmware

```
Firmware Images: Information
                 Select           (◄►E)
```

Information	Permits the user to select and view information on the firmware and software used by the modem.
Bootrom	Displays: the release date, The Firmware number and the revision number.
Image#1/ Image#2	Displays: the **Bulk, App, M&C, Mod, Demod, Decoder, Filters, TxIntfc, RxIntfc,** and **Turbo** information.
Select	Permits the user to select and which image will be loaded into the modem.

Select: Utility: Firmware: Information: Bootrom

```
Bootrom:        05/13/05
FW11186-1-        1.1.1
```

Select: Utility: Firmware: Information: Image#1

```
Image#1: Bulk App M&C Mod Demod Decoder
Filters TxIntfc RxIntfc Turbo       (◄ ►E)
```

Image#	The following information is displayed: the firmware number including the revision, the release date and the version number. Both images have similar information with only the revision and the release date being different
Bulk	FW/11188D, 01/11/05,1.1.5c (The bulk is the sum of all the individual pieces).
App	FW/11187D, 01/11/05,1.1.5c
M&C	FW/11185-, 10/13/05,1.1.1
Mod	FW/11179-, 10/13/05,1.1.1
Demod	FW/11181A, 11/07/05,1.1.2
Decoder	FW/11182C, 12/15/05,1.1.4
Filters	FW/11179-, 10/13/05,1.1.1 FW/11181A, 11/07/05,1.1.2
TxIntfc	FW/11180C, 01/05/06,1.1.4a
RxIntfc	FW/11183B, 11/16/05,1.1.3
Turbo	FW/11184C, 12/12/05,1.1.4

Select: Utility: Firmware: Select

```
Current Active Image#2
Next Reboot Image#1 #2                    (◄ ►E)
```

To reboot the modem, cycle the power.

IMPORTANT

4.3.4.2   Select: Utility: FAST

```
FAST: Configuration         S/N 000000012
      View Options               (◄ ►E)
```

Select: Utility: FAST: Configuration

```
FAST Configuration:   Enter Modem Code
Enter TURBO Code      Demo Mode      (◄ ►E)
```

Modem Code	This is a 20 digit code, that allows upgrading the modem functionality, which can be purchased from Comtech EF Data . Legal characters are hexadecimal, 0-F.
TURBO Code	This is a 20 digit code, that allows upgrading the maximum allowable data rate of the TURBO FEC. This code can be purchased from Comtech EF Data. Legal characters are hexadecimal, 0-F.
Demo Mode	Demonstration mode is a unique Comtech EF Data feature that allows the user to try out any capability of the installed hardware for up to 168 hours (7, 24 hour days).

Select: Utility: FAST: Configuration: View Options

```
View Options: 01      Installed
Full Range Data Rate
```

Options	This will list the options that the modem supports and identifies if they are enabled. There are 14 options, listed 01 – 14.
01	Modem Data Rate, 5 Mbps, 10 Mbps, 20 Mbps, 52 Mbps.
02	8-PSK modulation
03	8-QAM modulation **(future)**
04	16-QAM modulation
05	64-QAM modulation **(future)**
06	AUPC overhead (Automatic Uplink Power Control)
07	MIL-188-165A Overhead mode **(future)**
08	IESS-308 Overhead mode
09	IESS-309 Overhead mode
10	Reed Solomon Forward Error Correction
11	Asymmetrical Loop Timing
12	Turbo FEC card #1
13	Turbo Data Rate, 5 Mbps, 10 Mbps, 20 Mbps, 52 Mbps.
14	Interface Card, GigaBit Ethernet (The displayed interface will only reflect what is plugged into the modem).

Options 8,9,10 and 11 should be standard with the base modem and do not need to occupy a FAST option slot.

IMPORTANT

4.3.4.3 Display Screen Saver Status

Modem Status	The screen saver has two functions, one is to keep a fixed image from "burning" the screen, and the second is to provide a running status of the modem by scrolling the information sideways. This function supports seven different status category updates.
01	Circuit Identification
02	Demodulator receive frequency offset from the nominal
03	Buffer fill status
04	Receive signal level
05	Estimated Eb/No
06	Estimated Corrected Bit error Rate
07	Bit Error Rate reported by the internal Bit Error Rate Test set

Chapter 5. MAINTENANCE

This chapter contains system checkout, fault isolation, and identification information.

5.1   System Checkout

This section provides instructions for checking the modem setup within the earth station. Due to the complexity of the modem circuitry, the checkout procedure should be used only as a basic guideline. Maintenance tests that are more complicated are beyond the scope of this manual.

The system checkout consists of test instructions for the interface PCB, modem PCB, TURBO PCB, and L-Band IF PCB. The instructions include tables and test points for ensuring that the E_b/N_0, typical output spectrums, typical eye patterns, and constellations are correct. If a test failure occurs, refer to for fault isolation procedures.

⚠️ **CAUTION**   *This equipment contains parts and assemblies sensitive to damage by ESD. Use ESD precautionary procedures when touching, removing, or inserting PCBs.*

5.1.1 Checkout

5.1.2 Interface Checkout

Use the following procedure and the test setup in Figure 5-1 to verify the data interface.

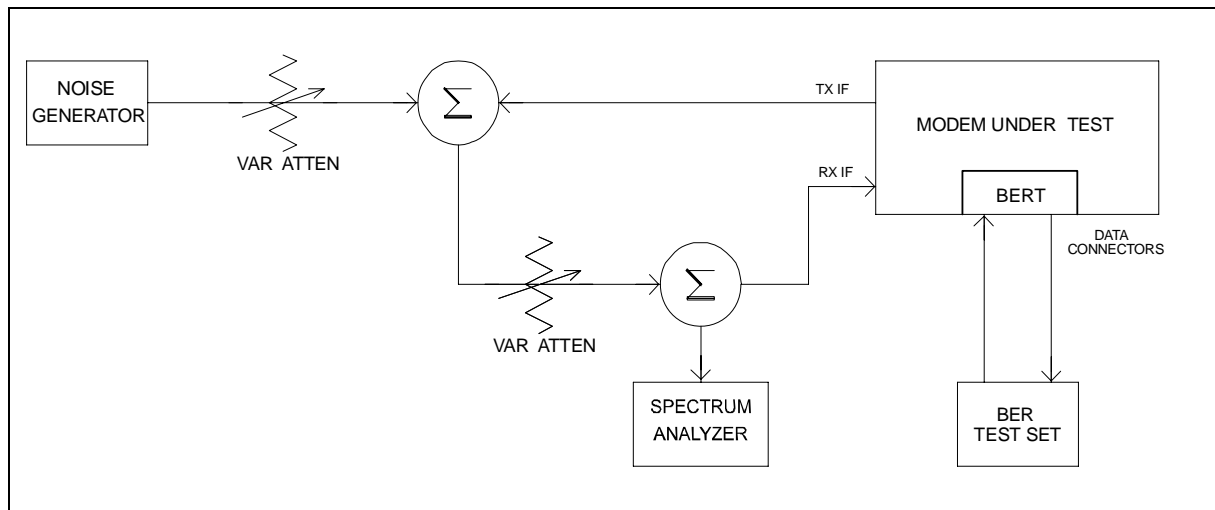**Figure 5-1. Fault Isolation Test Setup**

Notes:
1. Ensure the correct data and IF interface is selected and configured for the proper mode of operation.
2. Connect a BER test set to the appropriate modem data connector as shown in Figure 5-1.
3. Set up the modem for baseband loopback operation by selecting I/O1 in the **Test\Loopback\I/O1:** from the front panel menu. The modem will run error free.

5.1.3 Modulator Checkout

Use the following procedure to check out the modulator:

Step	Procedure
1	Set up the equipment as shown in Figure 5-1 using 70/140 MHz IF interface. Refer to Chapter 1 for the modulator specifications.
2	Set up the modem for IF loopback operation by using the **Test\Loopback\IF** from the front panel menu, or use an external IF loop.
3	Clear all TX faults, Stored Faults, and Alarms using the clear **Monitor\Event-Log:** from the front panel menu.
4	Measure the E_b/N_0 with a receiver that is known to be properly operating.
	a. Refer to Table 5-1 and Figure 5-2 to check for proper E_b/N_0 level. The (S+N)/N is measured by taking the average level of the noise and the average level of the modem spectrum top.
	b. Use this measurement for the first column on Table 5-1.
	c. Read across the page to find the S/N and E_b/N_0 for the specific code rate.
	Note: Once the demodulator has locked to the incoming signal, the **Monitor\Rx-Params:** menu will display frequency offset, signal level, BERT data if enabled, buffer status, E_b/N_0, and corrected BER.
6	Connect a spectrum analyzer to the modem as shown in Figure 5-1. Ensure the IF output meets the appropriate mask and spurious specifications. Measure the power output at different levels and frequencies.
	Note: A typical output spectrum is shown in Figure 5-3.
7	Check the frequency and phase modulation accuracy as follows:
	a. Set the modem to the continuous wave mode by using the **Test\Carrier\Tx-CW:** from the front panel menu. This sets the Carrier modulation in the OFF condition. A pure carrier should now be present at the IF output. This should only be used for frequency measurements. Spurious and power measurements should be taken with the modulation on.
	b. Set the modem to the continuous wave Offset mode by using the **Test\Carrier\Tx-1,0:** from the front panel menu. This generates a single upper side band and suppressed carrier signal. Ensure the carrier and side-band suppression are < -30 dBc.
8	Repeat steps 2-7 using the L-Band IF interface.

Table 5-1. Conversion to S/N and E_b/N_0 Chart

(dB)	Code	Rate 1/2	Code	Rate 3/4	Code	Rate 7/8
(S+N)/N	S/N	E_b/N_0	S/N	E_b/N_0	S/N	E_b/N_0
4.0	1.8	1.8	1.8	0.0	1.8	-0.6
4.5	2.6	2.6	2.6	0.8	2.6	0.2
5.0	3.3	3.3	3.3	1.6	3.3	0.9
5.5	4.1	4.1	4.1	2.3	4.1	1.6
6.0	4.7	4.7	4.7	3.0	4.7	2.3
6.5	5.4	5.4	5.4	3.6	5.4	3.0
7.0	6.0	6.0	6.0	4.3	6.0	3.6
7.5	6.6	6.6	6.6	4.9	6.6	4.2
8.0	7.3	7.3	7.3	5.5	7.3	4.8
8.5	7.8	7.8	7.8	6.1	7.8	5.4
9.0	8.4	8.4	8.4	6.7	8.4	6.0
9.5	9.0	9.0	9.0	7.2	9.0	6.6
10.0	9.5	9.5	9.5	7.8	9.5	7.1
10.5	10.1	10.1	10.1	8.3	10.1	7.7
11.0	10.6	10.6	10.6	8.9	10.6	8.2
11.5	11.2	11.2	11.2	9.4	11.2	8.8
12.0	11.7	11.7	11.7	10.0	11.7	9.3
12.5	12.2	12.2	12.2	10.5	12.2	9.8
13.0	12.8	12.8	12.8	11.0	12.8	10.3
13.5	13.3	13.3	13.3	11.5	13.3	10.9
14.0	13.8	13.8	13.8	12.1	13.8	11.4
14.5	14.3	14.3	14.3	12.6	14.3	11.9
15.0	14.9	14.9	14.9	13.1	14.9	12.4
15.5	15.4	15.4	15.4	13.6	15.4	12.9
16.0	15.9	15.9	15.9	14.1	15.9	13.5
16.5	16.4	16.4	16.4	14.6	16.4	14.0
17.0	16.9	16.9	16.9	15.2	16.9	14.5
17.5	17.4	17.4	17.4	15.7	17.4	15.0
18.0	17.9	17.9	17.9	16.2	17.9	15.5
18.5	18.4	18.4	18.4	16.7	18.4	16.0
19.0	18.9	18.9	18.9	17.2	18.9	16.5
19.5	19.5	19.5	19.5	17.7	19.5	17.0
20.0	20.0	20.0	20.0	18.2	20.0	17.5

RL -49.00 dBm

ATTEN 10 dB
2.00 dB/DIV

RES BANDWIDTH
10.0 kHz

Modem Rate = 2144 kbit/s, 3/4 Rate Coding
with 7.7 dB Eb/No (S + N)/N = 10 dB

CENTER 70.000 MHz   SPAN 1.000 MHz
*RB 10.0 kHz   *VB 10.0 Hz   ST 30.00 sec
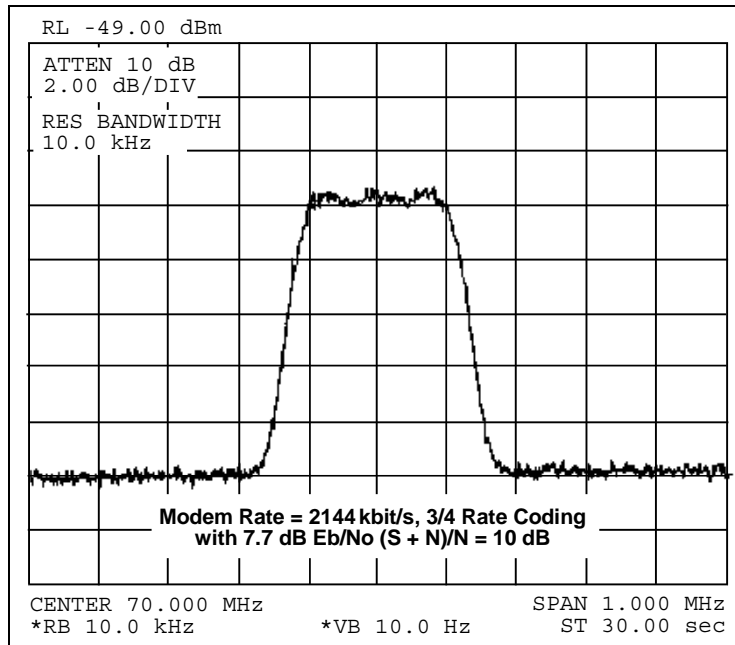
Figure 5-2. Typical Output Spectrum (with Noise)

RL -20.29 dBm

ATTEN 10 dB
5.00 dB/DIV   PASS

CENTER FREQUENCY
140.000 MHz

CENTER 140.000 MHz   SPAN 5.000 MHz
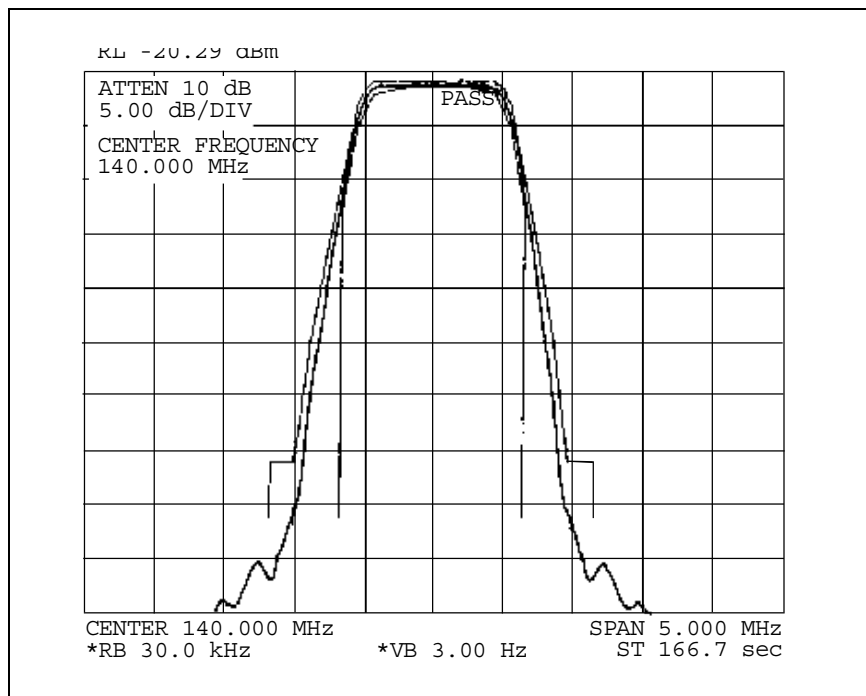*RB 30.0 kHz   *VB 3.00 Hz   ST 166.7 sec

Figure 5-3. Typical Output Spectrum (without Noise)

5.2   Demodulator Checkout

Test the demodulator as follows:

| Step	Procedures
1	Set up the equipment as shown in Figure 5-1 using the 70/140 MHz IF interface.
2	Set up the modem with an external IF loop and level. Use a properly operating modulator, and ensure that power levels, data rates, code rates, etc. are compatible.
3	Allow the modem to lock up. a. Depending on the data rate and overhead type, lock-up may take several seconds. b. When the GREEN IF and Data Lock LED are ON and any fault has been cleared (where applicable), the modem will run at the specified error rate. c. Run the Rx power level (input amplitude) over the full range and offset the Tx frequency from the nominal Rx frequency by up to ±30 kHz. d. Ensure the modem still runs within the specified error rate.
4	Set up the modem to check the constellation by hooking an oscilloscope that is set in the X-Y mode to J9 pins 3 and 8. An alternative method is to use a computer and the IQ Mon program with an Ethernet connection to the modem. Typical constellation patterns with noise and without noise are shown in Figure 5-4.
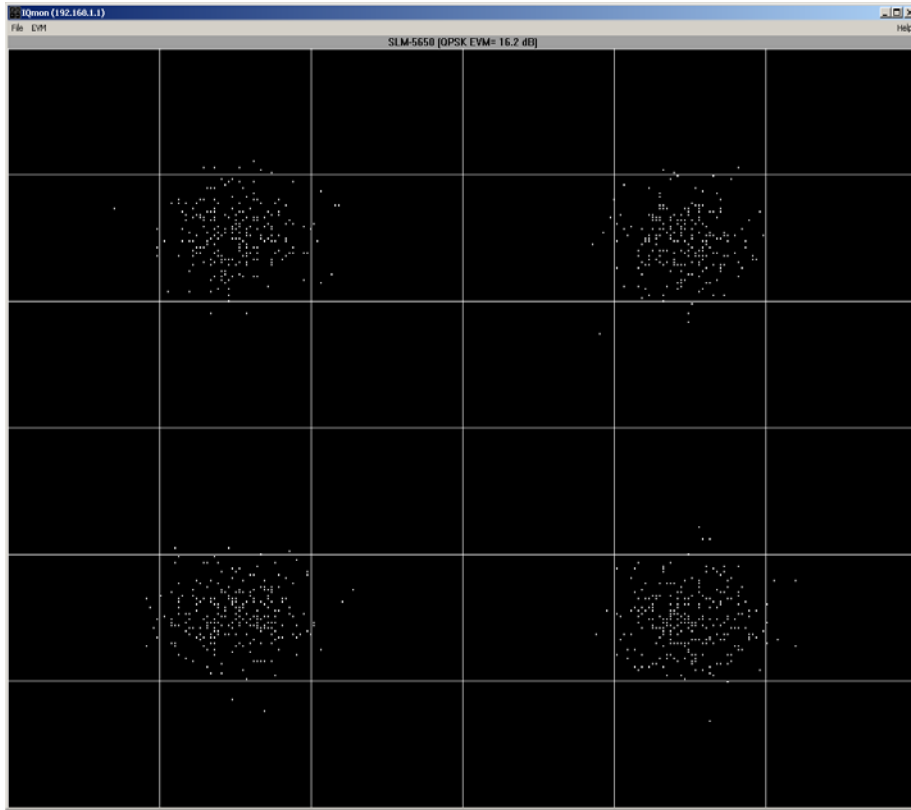
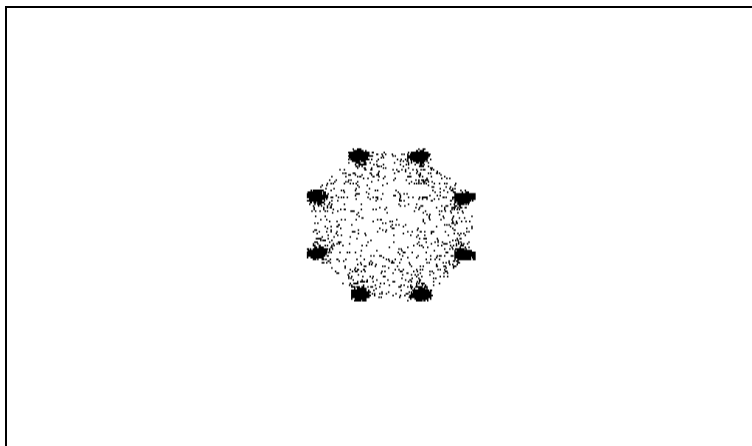PC version IQ monitor with noise
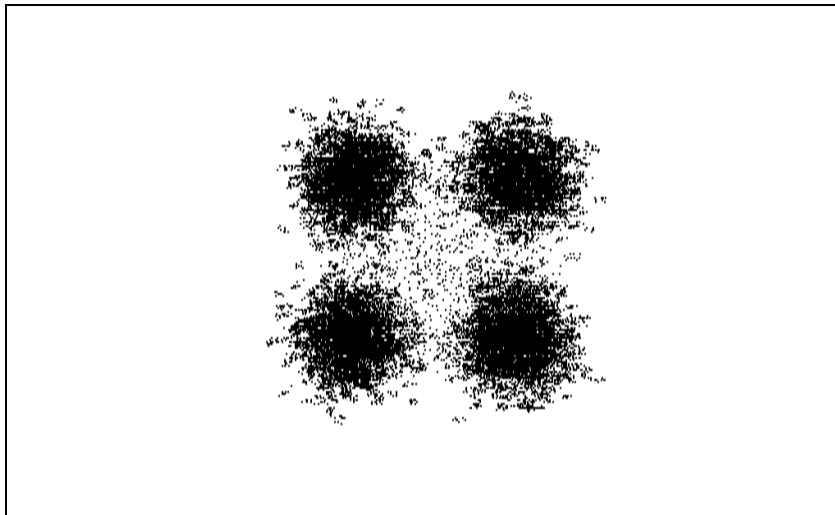
Oscilloscope WITH NOISE

Figure 5-4. Typical Constellation Patterns with Noise and without Noise
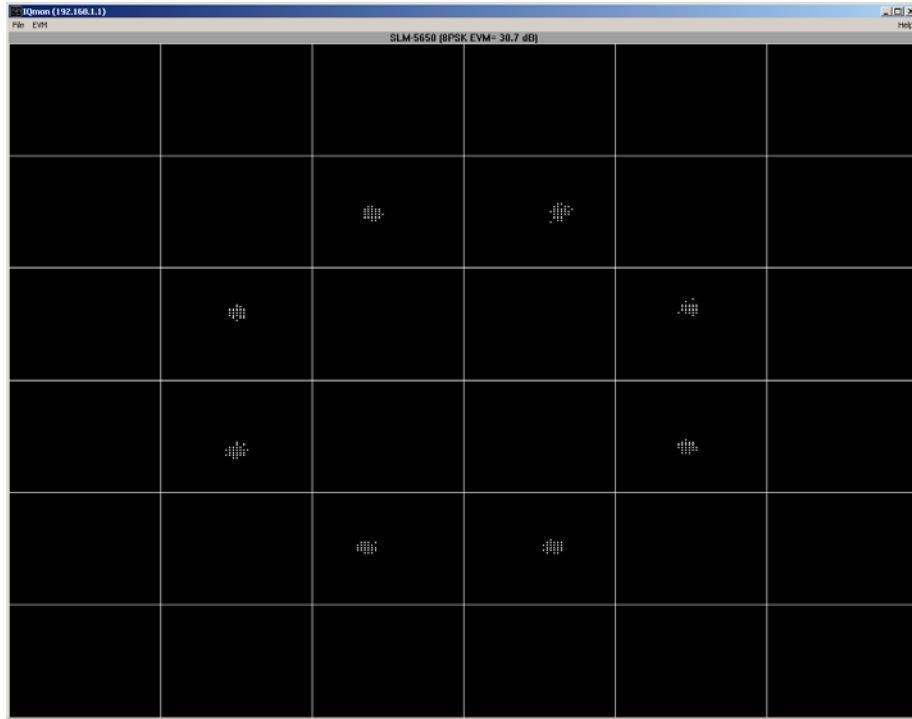
PC version IQ monitor WITHOUT NOISE

Oscilloscope WITHOUT NOISE

Figure 5-4. Typical Constellation Patterns with Noise and without Noise (Cont)

5.3   Fault Isolation

The design of the modem allows for removal and replacement of some faulty components in the field. The optional interface PCB's can be removed from the modem through the rear panel, without requiring special tools. The TURBO PCB and power supply can be replaced if the top cover is removed.

> ⚠️ **CAUTION**
>
> *This equipment contains parts and assemblies sensitive to damage by ESD. Use ESD precautionary procedures when touching, removing, or inserting PCBs.*

The fault monitoring capability of the modem assists the operator in determining which PCB has failed. If possible, replace the faulty PCB and return the damaged board to the Comtech EF Data Customer Support Department for repair. If not return the complete modem.

The fault isolation procedure lists the following categories of faults or alarms.

- Modulator
- Demodulator
- Transmit Interface
- Receive Interface
- Unit (Common Equipment)

Notes:
1. Each fault or alarm category includes possible problems and the appropriate action required to repair the modem.
2. If any of the troubleshooting procedures mentioned earlier in this chapter do not isolate the problem, and Comtech EF Data Customer Support assistance is necessary, have the following information available for the representative:

- Modem configuration. Modem configuration includes the modulator, demodulator, interface, or local AUPC sections.

- Faults (active or stored).

5.4   System Faults/Alarms

System faults are reported in the "Monitor/Alarms" menu, and stored faults are reported in the "Monitor/Event-Log" menu. To determine the appropriate action for repairing the modem, refer to Table 5-2 and the list of possible problems.

Table 5-2. SLM-5650 Fault Tree

	TX IF OUTPUT OFF	TX STATUS LED	TX FAULT RELAY (1)	RX STATUS LED	RX FAULT RELAY (2)	UNIT STATUS LED	UNIT FAULT RELAY (3)	AUDIBLE ALARM	TX AIS	RX AIS
MODULATOR FAULTS										
NONE		GREEN								
MOD SYMBOL CLOCK PLL	X	RED	X					X	X	
MOD SYNTHESIZER PLL	X	RED	X					X	X	
MOD I/Q ACTIVITY	X	RED	X					X	X	
MOD FILTER CLIPPING	X	RED	X					X	X	
TX INTERFACE CLOCK PLL		RED	X					X	X	
TX INTF CLOCK ACTIVITY		YELLOW	X						X	
TX INTERFACE SCT PLL		RED	X					X	X	
TX INTERFACE DATA AIS		YELLOW	X							
DEMODULATOR FAULTS										
NONE				GREEN						
DEMOD CARRIER LOCK				RED	X			X		X
DEMOD DECODER LOCK				RED	X			X		X
DEMOD SYNTHESIZER PLL				RED	X			X		X
DEMOD I/Q ACTIVITY				RED	X			X		X
DEMUX LOCK				RED	X			X		X
BUFFER				RED	X			X		X
BUFFER FILL				YELLOW	X					
BUFFER OVERFLOW				YELLOW	X					
BUFFER UNDERFLOW				YELLOW	X					
BUFFER PLL				RED	X			X		X
BUFFER CLK REF ACTIVITY				YELLOW	X					
RX INTERFACE DATA AIS				YELLOW	X					
Eb/No THRESHOLD				YELLOW	X					

Legend		
Test Note	**Fault/Alarm Relay**	**Test Points Connector/Pins**
1	TX FAULT	J8/Pin 2 (NO), 1 (COM), 6 (NC) ****
2	RX FAULT	J8/Pin 5 (NO), 4 (COM), 9 (NC) ****
3	UNIT FAULT	J8/Pin 8 (NO), 7 (COM), 3 (NC) ****
****	A connection between the common and N.O. contacts indicate no fault/alarm.	

Table 5-2. SLM-5650 Fault Tree (Continued)

UNIT FAULTS	TX IF OUTPUT OFF	TX STATUS LED	TX FAULT RELAY (1)	RX STATUS LED	RX FAULT RELAY (2)	UNIT STATUS LED	UNIT FAULT RELAY (3)	AUDIBLE ALARM	TX AIS	RX AIS
NONE	X					GREEN				
+5.0V POWER	X					RED	X	X		
+3.3V POWER	X					RED	X	X		
+2.5V POWER	X					RED	X	X		
+1.5V POWER	X					RED	X	X		
+12V POWER	X					RED	X	X		
-12V POWER	X					RED	X	X		
+18V POWER	X					RED	X	X		
COOLING FAN						RED	X	X		
EXTERNAL REF ACTIVITY						YELLOW	X	X		
192 MHZ CLOCK PLL	X					RED	X	X		
10 MHZ REF PLL	X					RED	X	X		
M&C FPGA CONFIG	X					RED	X	X		
MOD FPGA CONFIG	X					RED	X	X		
DEMOD FPGA CONFIG						RED	X	X		
DECODER FPGA CONFIG						RED	X	X		
TX INTF FPGA CONFIG	X					RED	X	X		
RX INTF FPGA CONFIG						RED	X	X		
FEC #1 FPGA CONFIG	X**					RED	X	X		
FEC #2 FPGA CONFIG	X**					RED	X	X		
OPTION CARD FPGA CONFIG						RED	X	X		
FPGA DCM phase Lock Loop Fault						RED				

Legend		
Test Note	**Fault/Alarm Relay**	**Test Points Connector/Pins**
1	TX FAULT	J8/Pin 2 (NO), 1 (COM), 6 (NC) ****
2	RX FAULT	J8/Pin 5 (NO), 4 (COM), 9 (NC) ****
3	UNIT FAULT	J8/Pin 8 (NO), 7 (COM), 3 (NC) ****

**** A connection between the common and N.O. contacts indicate no fault/alarm.
** The IF output is only affected if that particular FEC card is currently passing traffic.

5.4.1   LED Display and Description

The 8 LED's indicate fault, status, and alarm information located on the modem's front panel.

COLOR	STATUS LED's
RED	A RED COLOR indicates a fault currently exists. It is stored in the Event Log memory.
YELLOW	A YELLOW COLOR indicates an alarm currently exists. It is stored in the Event Log memory.
GREEN	A GREEN COLOR indicates no faults or alarms currently exist.

A total of 255 occurrences of any fault can be stored. Each fault or stored fault indicated by a front panel LED could be one of many faults. Use the Fault or Stored Fault front panel menu to determine which fault has occurred.

Alarms are considered minor faults. Alarms are shown in the Fault or Stored Fault front panel menu by a reversed-contrast "+" that appears at the display panel (white on black).

LED	Description
Tx On	Modulator output status, if illuminated output is turned on.
IF LOCK	Demodulator Carrier Detect, if illuminated the carrier is locked
DATA LOCK	Decoder Data lock, if illuminated the decoder is locked.
REMOTE	Modem remote control status. If the LED is green the modem is in local control, if yellow the modem is in remote control.
TEST MODE	Modem test mode indicator, if illuminated a test mode is enabled.

Notes:

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Appendix A. OPTIONS

A.1   Forward Error Correction Options

As standard, the SLM-5650 Modem is equipped with three Forward Error Correction encoders/decoders – Viterbi, concatenated Reed-Solomon, and Trellis (which is available with the 8-PSK FAST option). The constraint lengths and encoding polynomials are not only Open Network compatible, but are also Closed Network compatible with the vast majority of existing modems from other manufacturers. The SLM-5650 also provides the capability to disable all FEC allowing the modem to run uncoded.

Turbo Coding represents a very significant development in the area of FEC, and optionally, the SLM-5650 may be fitted with the Turbo Product Codec. It is a plug-in daughter card (SIMM module), which can be upgraded in the field. There are four speed grades of the Turbo FEC. The data rate capabilities are from:

Low Rate	64 kbps to 5 Mbps
Low Rate	64 kbps to 10 Mbps
Low Rate	64 kbps to 20 Mbps
High Rate	64 kbps to 51.84 Mbps

A.2   Viterbi

The combination of convolutional coding and Viterbi decoding has become an almost universal standard for satellite communications. The SLM-5650 complies with the Intelsat IESS 308 and 309 standards for Viterbi decoding with a constraint length of seven. This is a *de facto* standard, which means inter-operability with other manufacturer's equipment. It provides very useful levels of coding gain, and its short decoding delay and error-burst characteristics make it particularly suitable for low data rate coded voice applications. It has a short constraint length, fixed at 7, for all code rates. (The constraint length is defined as the number of output symbols from the encoder that are affected by a single input bit.)

By choosing various coding rates (Rate 1/2, 3/4 or 7/8) the user can trade off coding gain for bandwidth expansion. Rate 1/2 coding gives the best improvement in error rate, but doubles the transmitted data rate, and hence doubles the occupied bandwidth of the signal. Rate 7/8 coding, at the other extreme, provides the most modest improvement in performance, but only expands the transmitted bandwidth by 14 %. A major advantage of the Viterbi decoding method is that the performance is independent of data rate, and does not display a pronounced threshold effect (i.e., does not fail rapidly below a certain value of Eb/No). Note that in BPSK mode, the SLM-5650 permits code rates of 1/2, 3/4, and 7/8.

Because the method of convolutional coding used with Viterbi, the encoder does not preserve the original data intact, and is called *non-systematic*.

Table A-1. Viterbi Decoding Summary

FOR	AGAINST
Good BER performance - very useful coding gain.	Higher coding gain possible with other methods
Almost universally used, with *de facto* standards for constraint length and coding polynomials	
Shortest decoding delay (~100 bits) of any FEC scheme - good for coded voice, VOIP, etc	
Short constraint length produce small error bursts - good for coded voice.	
No pronounced threshold effect - fails gracefully.	
Coding gain independent of data rate.	

A.3   Reed-Solomon Outer Codec

The concatenation of an outer Reed-Solomon (R-S) Codec with a Viterbi decoder first became popular in the early 1990's. It permits significant improvements in error performance without significant bandwidth expansion.

The coding overhead added by the R-S outer Codec is typically around 10%, which translates to a 0.4 dB power penalty for a given link. Reed-Solomon codes are block codes (as opposed to Viterbi and Sequential, which are convolutional), and in order to be processed correctly the data must be framed and de-framed. Additionally, R-S codes are limited in how well they can correct errors that occur in bursts.

This, unfortunately, is the nature of the uncorrected errors from Viterbi decoders, which produce clusters of errors that are multiples of half the constraint length. For this reason, the data must be interleaved following R-S encoding, and is then de-interleaved prior to decoding. This ensures that a single burst of errors leaving the Viterbi decoder is spread out over a number of interleaving frames, so errors entering the R-S decoder do not exceed its capacity to correct those errors.

In the case of the SLM-5650, different R-S code rates are used, according to the mode of operation:

Closed Network Modes

A 225,205 code is used in closed network mode. For a rate of 225,205 data is put into blocks of 225 bytes, of which 205 bytes are data, and 20 bytes are FEC overhead. The code was chosen because it is compatible with legacy Comtech EF Data modems.

For closed network Viterbi Reed Solomon, an interleaver depth of 8 is used. The increase in coding gain is at the expense of delay. The interleaving/de-interleaving delay and the delay through the decoder itself can be as high as 25 kbps. At low data rates, this equates to an appreciable part of a second, when combined with the round trip delay makes it highly unsuitable for voice applications. Additionally, the de-interleaver frame synchronization method can add significantly to the time taken for the demodulator to declare acquisition.

Table A-2. Open Network Modes

Code Rate	Mode
219, 201 126, 112	IESS-308 Standard Lower Rates
225, 205 219, 201 194, 178	IESS-308 Standard Upper Rates
225, 205 219, 201 208, 192 194, 178 126, 112	IESS-308 Extended
219, 201	IESS-309 IBS, VSAT-IBS and Extended
219, 201	IESS-310

A characteristic of concatenated R-S coding is the very pronounced threshold effect. For any given modem design, there will be a threshold value of Eb/No below which the demodulator cannot stay synchronized. This may be due to the carrier-recovery circuits, or the synchronization threshold of the primary FEC device, or both. In the SLM-5650, and Rate 1/2 operation, this threshold is around 4 dB Eb/No. Below this value, operation is not possible, but above this value, the error performance of the concatenated R-S system produces exceptionally low error rates for a very small increase in Eb/No.

> ⚠ **CAUTION**
>
> *Care should be taken not to operate the demodulator near its sync threshold. Small fluctuations in Eb/No may cause total loss of the link, with the subsequent need for the demodulator to re-acquire the signal.*

Table A-3. Concatenated RS Coding Summary

FOR	AGAINST
Exceptionally good BER performance - several orders of magnitude improvement in link BER under given link conditions.	Very pronounced threshold effect - does not fail gracefully in poor Eb/No conditions. Additional coding overhead actually degrades sync threshold, and reduces link fade margin.
Very small additional bandwidth expansion	Significant processing delay (~25 kbps) - not good for voice, or IP applications
Interoperable with legacy Intelsat networks	Adds to demod acquisition time.

A.4   Trellis Coding (FAST Option)

In the other FEC methods described here, the processes of coding and modulation are independent - the FEC codec has no knowledge of, or interaction with the modulator. However, there are schemes in which the coding and modulation are combined together, where the encoder places FEC symbols in a precise manner into the signal constellation. This can yield an overall improvement in performance, and is used in higher-order modulation schemes, such as 8-PSK, 16-PSK, 16-QAM, etc.

When convolution coding is used, the overall *coded modulation* approach is referred to as Trellis Coded Modulation (TCM). Ungerboeck was an early pioneer, and developed optimum mapping and decoding schemes. However, the decoding scheme was seen as complex, and expensive, and Qualcomm Inc. developed a variation on the theme, which uses a Viterbi decoder at the core, surrounded by adjunct processing. The scheme is able to achieve performance very close to the optimum Ungerboeck method, but with far less complexity, and is called *pragmatic Trellis Coded Modulation*.

Intelsat recognized that, as more and more high power transponders are put in to service, the transponders are no longer *power limited*, but *bandwidth limited.* In order to maximize transponder capacity, they looked at 8-PSK as a method of reducing the occupied bandwidth of a carrier, and adopted Qualcomm's pragmatic TCM, at Rate 2/3.

A Rate 2/3 8-PSK/TCM carrier occupies only 50% of the bandwidth of a Rate 1/2 QPSK carrier. However, the overall coding gain of the scheme is not adequate by itself, and so Intelsat's IESS-310 specification requires that the scheme be concatenated with an outer RS codec. When combined, there is a threshold value of Eb/No of around 6 dB, and above approximately 7 dB, the bit error rate is better than 1×10^{-8}.

The detractions of the concatenated RS approach apply here also, along with more stringent requirements for phase noise and group delay distortion – the natural consequences of the higher-order modulation.

The SLM-5650 fully implements the IESS-310 specification at data rates up to 51.84 Mbps. In accordance with the specification, the R-S outer code can be disabled.

Table A-4. 8-PSK/TCM Coding Summary

FOR	AGAINST
Exceptionally bandwidth efficient compared to QPSK	Needs concatenated RS outer codec to give acceptable coding gain performance
Interoperable with legacy Intelsat networks	Demodulator acquisition threshold much higher than for QPSK
	8-PSK is more sensitive to phase noise and group delay distortion than QPSK

A.5   Turbo Product Codec (Hardware Option)

Turbo coding is an FEC technique developed within the last few years, which delivers significant performance improvements compared to more traditional techniques. Two general classes of Turbo Codes have been developed, Turbo Convolutional Codes (TCC), and Turbo Product Codes (TPC, a block coding technique). Comtech EF Data has chosen to implement an FEC codec based on TPC. A Turbo Product Code is a 2 or 3 dimensional array of block codes. Encoding is relatively straightforward, but decoding is a very complex process requiring multiple iterations of processing for maximum performance to be achieved.

Unlike the popular method of concatenating a R-S codec with a primary FEC codec, Turbo Product Coding is an entirely stand-alone method. It does not require the complex interleaving/de-interleaving of the R-S approach, and consequently, decoding delays are significantly reduced. Furthermore, the traditional concatenated R-S schemes exhibit a very pronounced threshold effect – a small reduction in Eb/No can result in total loss of demod and decoder synchronization. TPC does not suffer from this problem – the demodulator and decoder remain synchronized down to the point where the output error rate becomes unusable. This is considered to be a particularly advantageous characteristic in a fading environment. Typically, in QPSK, 8-PSK and 16-QAM TPC modes the demod and decoder can remain synchronized *2 – 3 dB below* the Viterbi/Reed-Solomon or TCM cases.

Table A-5. Available TPC Modes

TPC Code Rate/Modulation	Data Rate Range
Rate 5/16 BPSK	64 kbps to 9.375 Mbps
Rate 21/44 BPSK	64 kbps to 14.3 Mbps
Rate 21/44 QPSK, OQPSK	64 kbps to 28.636 Mbps
Rate 3/4 QPSK, OQPSK	64 kbps to 45.0 Mbps
Rate 3/4 8-PSK	256 kbps to 51.84 Mbps
Rate 3/4 16-QAM	256 kbps to 51.84 Mbps
Rate 7/8 QPSK, OQPSK	64 kbps to 51.84 Mbps
Rate 7/8 8-PSK	256 kbps to 51.84 Mbps
Rate 7/8 16-QAM	256 kbps to 51.84 Mbps
Rate 17/18 QPSK, OQPSK	64 kbps to 51.84 Mbps
Rate 17/18 8-PSK	256 kbps to 51.84 Mbps

Appendix B. REMOTE CONTROL

B.1   Introduction

This section describes the protocol and message command set for remote monitor and control of the SLM-5650 Modem.

The electrical interface is either an EIA-485 multi-drop bus (for the control of many devices) or an EIA-232 connection (for the control of a single device), and data is transmitted in asynchronous serial form, using ASCII characters. Control and status information is transmitted in packets, of variable length, in accordance with the structure and protocol defined in later sections.

B.2   EIA-485

For applications where multiple devices are to be monitored and controlled, a full-duplex (or 4-wire) EIA-485 is preferred. Half-duplex (2-wire) EIA-485 is possible, but is not preferred.

In full-duplex EIA-485 communication there are two separate, isolated, independent, differential-mode twisted pairs, each handling serial data in different directions. It is assumed that there is a 'controller' device (a PC or dumb terminal), which transmits data, in a broadcast mode, via one of the pairs. Many 'target' devices are connected to this pair, which all simultaneously receive data from the controller. The controller is the only device with a line-driver connected to this pair - the target devices only have line-receivers connected.

In the other direction, on the other pair, each target has a tri-stateable line driver connected, and the controller has a line-receiver connected. All the line drivers are held in high-impedance mode until one (and only one) target transmits back to the controller.

Each target has a unique address, and each time the controller transmits, in a framed 'packet' of data, the address of the intended recipient target is included. All of the targets receive the packet,

but only one (the intended) will reply. The target enables its output line driver, and transmits its return data packet back to the controller, in the other direction, on the physically separate pair.

EIA 485 (full duplex) summary:

- Two differential pairs - one pair for controller to target, one pair for target to controller.
- Controller-to-target pair has one line driver (controller), and all targets have line-receivers.
- Target-to-controller pair has one line receiver (controller), and all targets have tri-state drivers.

B.3   EIA-232

This much simpler configuration in which the controller device is connected directly to the target via a two-wire-plus-ground connection. Controller-to-target data is carried, via EIA-232 electrical levels, on one conductor, and target-to-controller data is carried in the other direction on the other conductor.

B.4   Basic Protocol

Whether in EIA-232 or EIA-485 mode, all data is transmitted as asynchronous serial characters, suitable for transmission and reception by a UART. In this case, the asynchronous character formats include 7O2, 7E2, and 8N1. The baud rate may vary between 2400 and 57,600 baud.

All data is transmitted in framed packets. The controller is assumed to be a PC or ASCII dumb terminal, which is in charge of the process of monitor and control. The controller is the only device, which is permitted to initiate, at will, the transmission of data. Targets are only permitted to transmit when they have been specifically instructed to do so by the controller.

All bytes within a packet are printable ASCII characters, less than ASCII code 127. In this context, the Carriage Return and Line Feed characters are considered printable.

All messages from controller to target require a response (with one exception). This will be either to return data, which has been requested by the controller, or to acknowledge reception of an instruction to change the configuration of the target. The exception to this is when the controller broadcasts a message (such as Set time/date) using Address 0, when the target is set to EIA-485 mode.

B.5   Packet Structure

Controller-to-target:

Start of Packet	Target Address	Address De-limiter	Instruction Code	Code Qualifier	Optional Arguments	End of Packet
< ASCII code 60 (1 character)	(4 characters)	/ ASCII code 47 (1 character)	(3 characters)	= or ? ASCII code 61 or 63 (1 character)	(n characters)	Carriage Return ASCII code 13 (1 character)

Example: <0135/TFQ=70.2345{CR}

Target-to-controller:

Start of Packet	Target Address	Address De-limiter	Instruction Code	Code Qualifier	Optional Arguments	End of Packet
> ASCII code 62 (1 character)	(4 characters)	/ ASCII code 47 (1 character)	(3 characters)	=, ?, !, or * ASCII code 61, 63, 33 or 42 (1 character)	(From 0 to n characters)	Carriage Return, Line Feed ASCII code 13,10 (2 characters)

Example: >0654/RSW=32{CR}{LF}

Each of the components of the packet is now explained.

B.5.1   Start Of Packet

Controller to Target: This is the character '<' (ASCII code 60)

Target to Controller: This is the character '>' (ASCII code 62)
Because this is used to provide a reliable indication of the start of packet, these two
characters may not appear anywhere else within the body of the message.

B.5.2   Address

Up to 9999 devices can be uniquely addressed. In EIA-232 applications this value is set
to 0. In EIA-485 applications, the permissible range of values is 1 to 9999. It is
programmed into a target unit using the front panel keypad.

IMPORTANT

The controller sends a packet with the address of a target - the destination of the packet. When the target responds, the address used is the same address, to indicate to the controller the source of the packet. The controller does not have its own address.

B.5.3 Instruction Code

This is a three-character alphabetic sequence, which identifies the subject of the message. Wherever possible, the instruction codes have been chosen to have some significance. For example TFQ for transmit frequency, RMD for receive modulation type, etc. This aids in the readability of the message, should it be displayed in its raw ASCII form. Only upper case alphabetic characters may be used (A-Z, ASCII codes 65 - 90).

B.5.4 Instruction Code Qualifier

This is a single character, which further qualifies the preceding instruction code.

Code Qualifiers obey the following rules:

From Controller to Target, the only permitted values are:

Symbol	Definition
= (ASCII code 61)	The '=' code is used as the Assignment Operator (AO) and is used to indicate that the parameter defined by the preceding byte should be set to the value of the argument (s) which follow it. Example: in a message from controller to target, TFQ=0950.0000 would mean "set the transmit frequency to 950 MHz."
? (ASCII code 63)	The '?' code is used as the Query Operator (QO) and is used to indicate that the target should return the current value of the parameters defined by the preceding byte. Example: in a message from controller to target, TFQ? Would mean "return the current value of the transmit frequency."

From Target to Controller, the only permitted values are:

Symbol	Definition
= (ASCII code 61)	The '=' code is used in two ways: a. If the controller has sent a query code to a target (Example: TFQ? (meaning 'what's the Transmit frequency?'), the target would respond with TFQ=xxxx.xxxx, where xxxx.xxxx represents the frequency in question. b. If the controller sends an instruction to set a parameter to a particular value, then, providing the value sent is valid, the target will acknowledge the message by replying with TFQ=(with no message arguments)
? (ASCII code 63)	If the controller sends an instruction to set a parameter to a particular value, then, if the value sent is not valid, the target will acknowledge the message by replying (for example) with TFQ? (with no message arguments). This indicates that there was an error in the message sent by the controller.
! (ASCII code 33)	If the controller sends an instruction code which the target does not recognize, the target will acknowledge the message by echoing the invalid instruction, followed by the ! character with: Example: XYZ!
* (ASCII code 42)	If the controller sends an instruction to set a parameter to a particular value, then, if the value sent is valid, BUT the modulator will not permit that particular parameter to be changed at this time, the target will acknowledge the message by replying (for example) with TFQ* (with message arguments).
# ASCI code 35)	If the controller sends a correctly formatted command, BUT the modulator is not in remote mode, it will not allow reconfiguration and will respond with TFQ#

B.5.5   Message Arguments

Arguments are not required for all messages. Arguments are ASCII codes for the characters 0 to 9 (ASCII 48 to 57), period (ASCII 46) and comma (ASCII 44).

B.5.6   End Of Packet

Controller to Target: This is the 'Carriage Return' character (ASCII code 13)

Target to Controller: This is the two-character sequence 'Carriage Return', 'Line Feed'. (ASCII code 13, and code 10.)   Both indicate the valid termination of a packet

B.6 Remote Commands

A	I	M	R	S
AET, B-34	IEP, B-28	MGC, B-36	RBM, B-19	SCT, B-12
AMN, B-34	IMG, B-24	MOM, B-7	RBO, B-18	SNO, B-24
AMT, B-34	IPA, B-20	MRC, B-19	RBS, B-19	SSI, B-29
AMX, B-33	ISP, B-29	MSK, B-29	RCB, B-22	SWR, B-24
ANP, B-33	ITF, B-7		RCI, B-18	
			RCK, B-19	
B	**L**	**N**	RCL, B-34	**T**
			RCR, B-15	
BBR, B-21	LCL, B-34	NUE, B-28	RCW, B-16	T2F, B-32
BEI, B-21	LOP, B-20	NUS, B-29	RDD, B-17	TBO, B-13
BER, B-23	LPC, B-33		RDI, B-18	TCI, B-13
BFS, B-23	LRS, B-24	**P**	RDF, B-18	TCR, B-9
BRS, B-21	LUF, B-26		RDR, B-15	TCK, B-12
BRX, B-20		PAT, B-21	RDS, B-17	TCW, B-10
BTX, B-20			REA, B-19	TDE, B-12
			RFB, B-7	TDI, B-13
C			RFM, B-14	TDF, B-13
			RFO, B-23	TDR, B-10
CAE, B-28			RFQ, B-14	TFM, B-8
CAS, B-30			RFT, B-14	TFQ, B-8
CID, B-21			RMD, B-15	TFT, B-9
CLD, B-22			RNE, B-28	T1F, B-31
COM, B-20			RNS, B-30	TIM, B-22
CST, B-22			RPB, B-35	TMD, B-9
			RPC, B-35	TMP, B-24
D			RPE, B-35	TPL, B-12
			RPL, B-35	TRD, B-11
DAY, B-22			RRD, B-16	TRS, B-10
			RRS, B-16	TSC, B-12
E			RSI, B-17	TSI, B-11
			RSL, B-23	TTC, B-31
E2F, B-32			RSW, B-18	TXF, B-27
EBA, B-23			RTC, B-31	TXO, B-14
EBN, B-23			RXF, B-27	
EID, B-25				
E1F, B-31				
ERF, B-32				
ERR, B-21				

Parameter Type	Command (Instruction Code and Qualifier)	Arguments for Command or Response to Query	Description of Arguments	Response to Command	Query (Instruction Code and Qualifier)	Response to Query

Modem Operating Mode	MOM=	1 byte, value 0 thru 7	Command or Query.
			Modem Operating Mode, where:
			
			x=Defines the operating mode, where:
			   0=OM-73
			   1=Mil-165A
			   2=IESS-308
			   3=IESS-309
			   4=IESS-310
			   5=TURBO
			   6=16QAM
			   7=AUPC
			
			Example: MOM=0 (sets OM-73 operating mode)
				MOM=
				MOM?
				MOM*
				MOM#
					MOM?	MOM=x
						(see description of arguments)

Modem RF Band	RFB=	1 byte, value 0 or 1	Command or Query.
			Modem RF Band, where:
			
			x=Defines the RF band, where:
			   0=70/140 MHz Band
			   1=L-Band (950 MHz – 2000 MHz)
			
			Example: RFB=0 (sets 70/140 Band)
				RFB=
				RFB?
				RFB *
				RFB #
					RFB?	RFB =x
						(see description of arguments)

Interface Type	ITF=	1 byte, value 0 thru 3	Command or Query.
			Interface Type, where:
			
			x=Defines the interface type, where:
			   0=EIA-530
			   1=HSSI
			   2=Unbalance G.703
			   3=Balanced G.703
			
			Example: ITF=0 (sets EIA-530 interface type)
				ITF=
				ITF?
				ITF*
				ITF#
					ITF?	ITF=x
						(see description of arguments)

Parameter Type	Command (Instruction Code and Qualifier)	Arguments for Command or Response to Query	Description of Arguments	Response to Command	Query (Instruction Code and Qualifier)	Response to Query
Tx Frequency	TFQ=	9 bytes	Command or Query. Tx Frequency, 52 to 88 MHz, 104 to 176 MHz, and 950 MHz to 2000 MHz. Resolution=100Hz. Example: TFQ=0140.9872	TFQ= TFQ? TFQ* TFQ#	TFQ?	TFQ=xxxx.xxxx (see description of arguments)
Tx Overhead Type	**TFM=**	**1 byte, value of 0 thru 2, 4**	**Command or Query.** **Tx Overhead Type, where:** **0=None (Unframed)** **1=IBS** **2=IDR** **4=AUPC** **Depending on Modem mode, not all of these selections will be valid.** **Example: TFM=0 (selects Unframed mode)**	**TFM=** **TFM?** **TFM*** **TFM#**	**TFM?**	**TFM=x** **(see description of arguments)**

Priority System = MOM (Highest priority), RFB, ITF, TFM, TFT, TMD, TCR, and TDR (Lowest Priority), indicated by **shading**. Any change to a higher priority parameter can override any of the parameters of lower priority.

Parameter Type	Command (Instruction Code and Qualifier)	Arguments for Command or Response to Query	Description of Arguments	Response to Command	Query (Instruction Code and Qualifier)	Response to Query
Tx FEC Type	TFT=	1 byte, value of 0 thru 2	Command or Query. Tx FEC coding type, where: 0=None (Uncoded) 1=Viterbi 2=Turbo Example: TFT=2 (which is Turbo coding)	TFT= TFT? TFT* TFT#	TFT?	TFT=x (see description of arguments)
Tx Modulation Type	TMD=	1 byte, value of 0 thru 4	Command or Query. Tx Modulation type, where: 0=BPSK 1=QPSK 2=OQPSK 3=8PSK 4=16QAM Depending on FEC type, not all of these selections will be valid. Example: TMD=1 (which is QPSK)	TMD= TMD? TMD* TMD#	TMD?	TMD=x (see description of arguments)
Tx Code Rate	TCR=	1 byte, value of 0 thru 8	Command or Query Tx Code Rate, where: 0 = 1/1 (Uncoded) 1 = 1/2 2 = 3/4 3 = 7/8 4 = 2/3 5 = 5/6 6 = 21/44 7 = 5/16 8 = 17/18 Depending on FEC type, not all of these selections will be valid. Example: TCR=1 (which is Rate 1/2)	TCR= TCR? TCR* TCR#	TCR?	TCR=x (see description of arguments)

Parameter Type	Command (Instruction Code and Qualifier)	Arguments for Command or Response to Query	Description of Arguments	Response to Command	Query (Instruction Code and Qualifier)	Response to Query
Tx Data Rate	TDR=	10 bytes	**Command or Query.** **Tx Data rate, in kbps.** **Resolution=1 bps.** **Example: TDR=002047.999 (which is 2047.999 kbps)**	TDR= TDR? TDR* TDR#	TDR?	TDR=xxxxxx.xxx (see description of arguments)
Tx Reed-Solomon Encoding	TRS=	1 byte, value of 0 or 1	Command or Query. Tx RS encoding 0=Off 1=On Depending on Modem mode, not all of these selections will be valid. Example: TRS=0 (RS encoding is Off)	TRS= TRS? TRS* TRS#	TRS?	TRS=x (see description of arguments)
Tx Reed-Solomon Code Word	TCW=	1 byte, value of 0 to 5	Command or Query. Tx RS encoding 0 = RS(225,205,10) 1 = RS(219,201,9) 2 = RS(208,192,8) 3 = RS(194,178,8) 4 = RS(126,112,7) 5 = RS(220,200,10) Depending on Modem mode, overhead type, and data rate, not all of these selections will be valid. Example: TCW=0 (This is a 'don't care' if RS is Off under TRS)	TCW= TCW? TCW* TCW#	TCW?	TCW=x (see description of arguments)

Parameter Type	Command (Instruction Code and Qualifier)	Arguments for Command or Response to Query	Description of Arguments	Response to Command	Query (Instruction Code and Qualifier)	Response to Query
Tx Reed-Solomon Interleaver Depth	TRD=	1 byte, value of 0 to 2	Command or Query. Tx RS encoding 0 = Interleaver Depth 4 1 = Interleaver Depth 8 2 = Interleaver Depth 16 Depending on Modem mode, overhead type, and data rate, not all of these selections will be valid. Example: TRD=0 (This is a 'don't care' if RS is Off under TRS)	TRD = TRD? TRD * TRD #	TRD?	TRD =x (see description of arguments)
Tx Spectrum Invert	TSI=	1 byte, value of 0 or 1	Command or Query. Tx Spectrum Invert selection, where: 0=Normal, 1=Tx Spectrum Inverted Example: TSI=0 (which is normal)	TSI= TSI? TSI* TSI#	TSI?	TSI=x (see description of arguments)
Tx Scrambler	TSC=	1 byte, value of 0 thru 6	Command or Query. Tx Scrambler state, where: 0 = Off 1 = OM-73 Scrambler 2 = V.35 Scrambler 3 = Modified V.35 (EFData Closed Network) 4 = Reed-Solomon Synchronous Scrambler 5 = IBS Overhead Synchronous Scrambler 6 = TURBO Scrambler Depending on Modem mode, FEC type, overhead type, and RS state, not all of these selections will be valid. Example: TSC=1 (OM-73 Scrambler On)	TSC= TSC? TSC* TSC#	TSC?	TSC=x (see description of arguments)

Parameter Type	Command (Instruction Code and Qualifier)	Arguments for Command or Response to Query	Description of Arguments	Response to Command	Query (Instruction Code and Qualifier)	Response to Query

Tx Differential Encoding	TDE=	1 byte	Command or Query.
			Tx Differential Encoding, where:
			
			x=Tx Differential Encoding, where:
			  0=Off
			  1=On
			
			Depending on FEC type or Modulation Type, not all of these selections will be valid.
			
			Example: TDE=1 (selects Tx Differential Encoding On)
				TDE=
				TDE?
				TDE*
				TDE#
					TDE?	TDE=x
						(see description of arguments)

Tx Power Level	TPL=	5 bytes	Command or Query. Tx Output power level, where: s=sign (+ / -) xx.x = Tx Output power level, +10.0 and –40.0 dBm. Example: TPL=-13.4	TPL= TPL? TPL* TPL#	TPL?	TPL=sxx.x (see description of arguments)

Tx Clock Source	TCK=	1 byte	Command or Query.
			Tx Clock Source, where:
			
			x=Tx Clock Source, where:
			  0=Internal
			  1=Tx Terrestrial
			
			Example: TCK=1 (selects Tx Terrestrial Clock Source)
				TCK=
				TCK?
				TCK*
				TCK#
					TCK?	TCK=x
						(see description of arguments)

Tx SCT Reference	SCT=	1 byte, value of 0 thru 2	Command or Query.
			SCT Clock Reference, where:
			
			x=SCT Clock Reference, where:
			  0=Internal
			  1=Data Source Synchronized
			  2=Rx-Satellite Clock
			
			Example: SCT=0 (selects Internal Modem Reference)
				SCT =
				SCT?
				SCT*
				SCT#
					SCT?	SCT=x
						(see description of arguments)

Parameter Type	Command (Instruction Code and Qualifier)	Arguments for Command or Response to Query	Description of Arguments	Response to Command	Query (Instruction Code and Qualifier)	Response to Query
Tx Clock Invert	TCI=	1 byte, value of 0 or 1	Command or Query. Invert Transmit Clock, where: x=Invert Transmit Clock, where: 　0=Normal 　1=Inverted Example: TCI=1 (selects Inverted TX Clock)	TCI = TCI? TCI* TCI#	TCI?	TCI=x (see description of arguments)
Tx Data Invert	TDI=	1 byte, value of 0 or 1	Command or Query. Invert Transmit Data, where: x=Invert Transmit Data, where: 　0=Normal 　1=Inverted Example: TDI=1 (selects Inverted TX Data)	TDI = TDI? TDI* TDI#	TDI?	TDI=x (see description of arguments)
Tx Data Fault	TDF=	1 byte, value of 0 thru 2	Command or Query. Transmit Data Fault, where: x=Transmit Data Fault, where: 　0=None 　1=DATA 　2=AIS Example: TDF=0 (selects Data Fault = None)	TDF = TDF? TDF* TDF#	TDF?	TDF=x (see description of arguments)
Tx BPSK Data Ordering	TBO=	1 byte, value of 0 or 1	Command or Query. Invert Transmit BPSK Data Ordering, where: x=Invert Transmit BPSK Data Ordering, where: 　0=Normal 　1=Inverted Example: TBO=1 (selects Inverted BPSK Ordering)	TBO = TBO? TBO* TBO#	TBO?	TBO=x (see description of arguments)

Parameter Type	Command (Instruction Code and Qualifier)	Arguments for Command or Response to Query	Description of Arguments	Response to Command	Query (Instruction Code and Qualifier)	Response to Query
Tx Carrier State	TXO=	1 byte, value of 0 thru 3	Command or Query. Tx Carrier State, where: 0=OFF due to front panel or remote control command 1=ON 2=RTS 3=OFF due to ext H/W Tx Carrier Off command (not a valid argument when used as a command) Example: TXO=1 (Tx Carrier ON)	TXO= TXO? TXO* TXO#	TXO?	TXO=x (see description of arguments)
Rx Frequency	RFQ=	9 bytes	Command or Query. Rx Frequency, 52 to 88 MHz, 104 to 176 MHz, and 950 MHz to 2000 MHz. Resolution=100Hz. Example: RFQ=0140.9872	RFQ= RFQ? RFQ* RFQ#	RFQ?	RFQ=xxxx.xxxx (see description of arguments)
Rx Framing Mode	**RFM=**	**1 byte, value of 0 thru 2, 4**	**Command or Query. Rx Overhead Type, where: 0=None (Unframed) 1=IBS 2=IDR 4=AUPC** **Depending on Modem mode, not all of these selections will be valid.** **Example: RFM=0 (selects Unframed mode)**	**RFM= RFM? RFM* RFM#**	**RFM?**	**RFM=x (see description of arguments)**
Rx FEC Type	**RFT=**	**1 byte, value of 0 thru 2**	**Command or Query. Rx FEC coding type, where: 0=None (Uncoded) 1=Viterbi 2=Turbo** **Example: RFT=2 (which is Turbo coding)**	**RFT= RFT? RFT* RFT#**	**RFT?**	**RFT=x (same format as command argument)**

Parameter Type	Command (Instruction Code and Qualifier)	Arguments for Command or Response to Query	Description of Arguments	Response to Command	Query (Instruction Code and Qualifier)	Response to Query
Rx Demod type	RMD=	1 byte, value of 0 thru 4	Command or Query. Rx Modulation type, where: 0=BPSK 1=QPSK 2=OQPSK 3=8PSK 4=16QAM Depending on FEC type, not all of these selections will be valid. Example: RMD=1 (which is QPSK)	RMD= RMD? RMD* RMD#	RMD?	RMD=x (see description of arguments)
Rx FEC Code Rate	RCR=	1 byte, value of 0 thru 8	Command or Query Rx FEC Code Rate, where: 0 = 1/1 (Uncoded) 1 = 1/2 2 = 3/4 3 = 7/8 4 = 2/3 5 = 5/6 6 = 21/44 7 = 5/16 8 = 17/18 Depending on FEC type, not all of these selections will be valid. Example: RCR=1 (which is Rate 1/2)	RCR= RCR? RCR* RCR#	RCR?	RCR=x (see description of arguments)
Rx Data Rate	RDR=	10 bytes	Command or Query. Rx Data rate, in kbps. Resolution=1 bps. Example: RDR=002047.999 (which is 2047.999 kbps)	N/A	RDR?	RDR=xxxxxx.xxx (see description of arguments)

Priority System = MOM (Highest priority), RFB, ITF, RFM, RFT, RMD, RCR, and RDR (Lowest Priority), indicated by shading. Any change to a higher priority parameter can override any of the parameters of lower priority.

Parameter Type	Command (Instruction Code and Qualifier)	Arguments for Command or Response to Query	Description of Arguments	Response to Command	Query (Instruction Code and Qualifier)	Response to Query
Rx Reed-Solomon Decoding	RRS=	1 byte, value of 0 or 1	Command or Query. Rx RS encoding 0=Off 1=On Depending on Modem mode, not all of these selections will be valid. Example: RRS=0 (RS encoding is Off)	RRS= RRS? RRS* RRS#	RRS?	RRS=x (see description of arguments)
Rx Reed-Solomon Code Word	RCW=	1 byte, value of 0 to 5	Command or Query. Rx RS encoding 0 = RS(225,205,10) 1 = RS(219,201,9) 2 = RS(208,192,8) 3 = RS(194,178,8) 4 = RS(126,112,7) 5 = RS(220,200,10) Depending on Modem mode, overhead type, and data rate, not all of these selections will be valid. Example: RCW=0 (This is a 'don't care' if RS is Off under TRS)	RCW = RCW? RCW * RCW #	RCW?	RCW=x (see description of arguments)
Rx Reed-Solomon Interleaver Depth	RRD=	1 byte, value of 0 to 2	Command or Query. Rx RS encoding 0 = Interleaver Depth 4 1 = Interleaver Depth 8 2 = Interleaver Depth 16 Depending on Modem mode, overhead type, and data rate, not all of these selections will be valid. Example: RRD=0 (This is a 'don't care' if RS is Off under RRS)	RRD = RRD? RRD * RRD #	RRD?	RRD =x (see description of arguments)

Parameter Type	Command (Instruction Code and Qualifier)	Arguments for Command or Response to Query	Description of Arguments	Response to Command	Query (Instruction Code and Qualifier)	Response to Query
Rx Spectrum Invert	RSI=	1 byte, value of 0 or 1	Command or Query. Rx Spectrum Invert, where: 0=Normal 1=Rx Spectrum Invert Example: RSI=0 (selects Normal)	RSI= RSI? RSI* RSI#	RSI?	RSI=x (see description of arguments)
Rx Descrambler	RDS=	1 byte, value of 0 thru 6	Command or Query. Rx Scrambler state, where: 0 = Off 1 = OM-73 Scrambler 2 = V.35 Scrambler 3 = Modified V.35 (EFData Closed Network) 4 = Reed-Solomon Synchronous Scrambler 5 = IBS Overhead Synchronous Scrambler 6 = TURBO Scrambler Depending on Modem mode, FEC type, overhead type, and RS state, not all of these selections will be valid. Example: RDS=1 (OM-73 Scrambler On)	RDS= RDS? RDS* RDS#	RDS?	RDS=x (see description of arguments)
Rx Differential Decoding	RDD=	1 byte, value of 0 or 1	Command or Query. Rx Differential Decoding, where: x=Rx Differential Decoding, where: 　0=Off 　1=On Depending on FEC type or Modulation Type, not all of these selections will be valid. Example: RDD=1 (selects Rx Differential Decoding On)	RDD= RDD? RDD* RDD#	RDD?	RDD=x (see description of arguments)

Parameter Type	Command (Instruction Code and Qualifier)	Arguments for Command or Response to Query	Description of Arguments	Response to Command	Query (Instruction Code and Qualifier)	Response to Query
Rx Clock Invert	RCI=	1 byte, value of 0 or 1	Command or Query. Invert Receive Clock, where: x=Invert Receive Clock, where: 0=Normal 1=Inverted Example: RCI=1 (selects Inverted RX Clock)	RCI = RCI? RCI* RCI#	RCI?	RCI=x (see description of arguments)
Rx Data Invert	RDI=	1 byte, value of 0 or 1	Command or Query. Invert Receive Data, where: x=Invert Receive Data, where: 0=Normal 1=Inverted Example: RDI=1 (selects Inverted RX Data)	RDI = RDI? RDI* RDI#	RDI?	RDI=x (see description of arguments)
Rx Data Fault	RDF=	1 byte, value of 0 thru 2	Command or Query. Receive Data Fault, where: x= Receive Data Fault, where: 0=None 1=DATA 2=AIS Example: RDF=0 (selects Data Fault = None)	RDF = RDF? RDF* RDF#	RDF?	RDF=x (see description of arguments)
Rx BPSK Data Ordering	RBO=	1 byte, value of 0 or 1	Command or Query. Invert Receive BPSK Data Ordering, where: x=Invert Receive BPSK Data Ordering, where: 0=Normal 1=Inverted Example: RBO=1 (selects Inverted BPSK Ordering)	RBO = RBO? RBO* RBO#	RBO?	RBO=x (see description of arguments)
Rx Demod Acquisition Sweep Range	RSW=	8 bytes	Command or Query. Rx acquisition sweep range of demodulator, in kHz, ranging from 0 to 60 kHz. Example: RSW=0060.000 (selects 60 kHz)	RSW= RSW? RSW* RSW#	RSW?	RSW=xxxx.xxx (see description of arguments)

Parameter Type	Command (Instruction Code and Qualifier)	Arguments for Command or Response to Query	Description of Arguments	Response to Command	Query (Instruction Code and Qualifier)	Response to Query
Rx Reacquisition Time	REA=	3 bytes	Command or Query. Rx reacquisition time, in Seconds, ranging from 0 to 999. Example: RSW=000 (selects 0 seconds)	REA= REA? REA* REA#	REA?	REA=xxx (see description of arguments)

Rx Clock Source	RCK=	1 byte, value of 0 thru 2	Command or Query.
			Rx Clock Source , where:
			x=Rx Clock Source, where:
			    0=Rx Satellite
			    1=Internal
			    2=Tx-Terrestrial
			    3=External Clock (only valid with the G.703 Option Card)
			
			Example: RCK=2 (selects Tx-Terrestrial)
				RCK=
				RCK?
				RCK*
				RCK#
					RCK?	RCK=x
						(see description of arguments)

Rx Buffer Programming Mode	RBM=	1 byte, value of 0 or 1	Command or Query. Rx Buffer Programming Mode, where: 0 = Buffer Size is programmed in Bits. 1 = Buffer Size is programmed in milliseconds. Example: RBM=0	RBM= RBM? RBM* RBM#	RBM?	RBM=x (see description of arguments)
Rx Buffer Size	RBS=	8 bytes	Command or Query. Rx Buffer Size (in either bits or milliseconds, see RBM command), where: xxxxxxxx=Rx Buffer Size Example: RBS=00000512	RBS= RBS? RBS* RBS#	RBS?	RBS=xxxxxxxx (see description of arguments)
Modem Reference Clock	MRC=	1 byte, value of 0 thru 3	Command or Query. Modem Reference Clock (For Frequency Accuracy), where: 0=Internal 1=External 1 MHz 2=External 5 MHz 3=External 10 MHz	MRC= MRC? MRC* MRC#	MRC?	MRC=x (see description of arguments)

Parameter Type	Command (Instruction Code and Qualifier)	Arguments for Command or Response to Query	Description of Arguments	Response to Command	Query (Instruction Code and Qualifier)	Response to Query
IP Address	IPA=	18 bytes, numerical	Command or Query. Used to set the IP address and network prefix for the 10/100 BaseTx Ethernet management port, in the format: xxx.xxx.xxx.xxx.yy, where: xxx.xxx.xxx.xxx is the IP address, and yy is the network prefix (0-31) Example: 010.006.030.001.24	IPA= IPA? IPA* IPA#	IPA?	IPA= xx.xxx.xxx.xxx.yy (see description of arguments)
Carrier Only Test Modes	COM=	1 byte, value of 0 thru 2	Command or Query. Test Mode, where: 0= Normal Mode (no test) 1=Tx CW 2=Tx Alternating 1,0 Pattern Example: COM=1 (CW Mode)	COM= COM? COM* COM#	COM?	COM=x (see description of arguments)
Loopback Test Modes	LOP=	1 byte, value of 0 thru 3	Command or Query. Loopback Test Modes, where: 0=Normal Mode (no test) 1=IF Loopback 2=I/O Loopback #1 3=I/O Loopback #2 Example: LOP=1 (IF Loopback)	LOP= LOP? LOP* LOP#	LOP?	LOP=x (see description of arguments)
Tx BERT State	BTX=	1 byte, value of 0 or 1	Command or Query. Tx BERT State, where: 0=Off 1=On Example: BTX=1 (Tx BERT On)	BTX= BTX? BTX* BTX#	BTX?	BTX=x (see description of arguments)
Rx BERT State	BRX=	1 byte, value of 0 or 1	Command or Query. Rx BERT State, where: 0=Off 1=On Example: BRX=1 (Rx BERT On)	BRX= BRX? BRX* BRX#	BRX?	BRX=x (see description of arguments)

Parameter Type	Command (Instruction Code and Qualifier)	Arguments for Command or Response to Query	Description of Arguments	Response to Command	Query (Instruction Code and Qualifier)	Response to Query
Rx BERT Reset	BRS=	None	Command only. Reset Rx BERT Example: BRS=	BRS= BRS? BRS* BRS#	N/A	N/A
Rx BERT Errors	N/A	7 bytes	Query only. Read the total number of Bit Errors. Example: ERR=9999999	N/A	ERR?	N/A
Rx BERT BER	N/A	6 bytes	Query only. Unit returns the value of the BERT BER in the form a.b x 10^{-c}. First three bytes are the value. Last two bytes are the exponent. Returns 0.0E00 if the BERT is not synchronized to a pattern. Example: BBR=4.9E12	N/A	BBR?	BBR=a.bEcc (see description of arguments)
BERT Pattern	PAT=	1 byte, value of 0 thru 8	Command or Query. BERT Pattern, where: 0=2047 1=Mark 2=Space 3=1:1 4=1:3 5=2^15-1 6=2^20-1 7=2^23-1 8=MIL-188 Example: PAT=0 (2047 Pattern)	PAT= PAT? PAT* PAT#	PAT?	PAT=x (see description of arguments)
Insert Tx BERT Error	BEI=	None	Command only. Insert single bit error in Tx BERT Example: BEI=	BEI= BEI? BEI* BEI#	N/A	N/A
Circuit ID String	CID=	24 bytes	Command or Query. Sets or queries the user-defined Circuit ID string, which is a fixed length of 24 characters. Valid characters include: Space ( ) * + − , . / 0 9 and A thru Z	CID= CID? CID* CID#	CID?	CID=x (see description of arguments)

Parameter Type	Command (Instruction Code and Qualifier)	Arguments for Command or Response to Query	Description of Arguments	Response to Command	Query (Instruction Code and Qualifier)	Response to Query
Configuration Save	CST=	1 byte	Command only. Command causes the modem to store the current configuration in Configuration Memory location defined by the one-byte argument (0 to 9). Example: CST=4 (store the current configuration in location 4)	CST= CST? CST* CST#	N/A	N/A
Configuration Load	CLD=	1 byte	Command only. Causes the modem to retrieve a previously stored configuration from Configuration Memory location defined by the one-byte argument (0 to 9). Example: CLD=4 (retrieve modem configuration from location 4)	CLD= CLD? CLD* CLD#	N/A	N/A
ReCenter Buffer	RCB=	None	Command only. Forces the software to recenter the receive Plesiochronous/Doppler buffer. Example: RCB= (ReCenter buffer)	RCB= RCB? RCB* RCB#	N/A	N/A
RTC Date	DAY=	6 bytes	Command or Query. A date in the form ddmmyy, where dd = day of the month (01 to 31), mm = month (01 to 12) yy = year (00 to 99) Example: DAY=240457 (April 24, 2057)	DAY= DAY? DAY* DAY#	DAY?	DAY=ddmmyy (see description of arguments)
RTC Time	TIM=	6 bytes	Command or Query. A time in the form hhmmss, indicating the time from midnight, where: hh = hours (00 to 23) mm = minutes (00 to 59) ss = seconds (00 to 59) Example: TIM=231259 (23 hours:12 minutes:59 seconds)	TIM= TIM? TIM* TIM#	TIM?	TIM=hhmmss (see description of arguments)

Parameter Type	Command (Instruction Code and Qualifier)	Arguments for Command or Response to Query	Description of Arguments	Response to Command	Query (Instruction Code and Qualifier)	Response to Query
Eb/No Alarm Point	EBA=	4 bytes	Command or Query. Eb/No alarm point in dB, with a range between 0.1 and 20 dB. Resolution=0.1 dB Example: EBA=12.3	EBA= EBA? EBA* EBA#	EBA?	EBA=xx.x (see description of arguments)
Rx Eb/No	N/A	4 bytes	Query only. Unit returns the value of Eb/No, between 0 and 20 dB, resolution 0.1 dB. Returns 99.9 if demod is unlocked. Example EBN=12.3 (which is Eb/No = 12.3 dB) For values greater than 20.0 dB, the reply will be: EBN=+020	N/A	EBN?	EBN=xxxx (see description of arguments)

Rx Signal Level	N/A	5 bytes	Query Only.
			Unit returns the value of the Rx signal level, in dBm, between +10.0 and –60.0 dBm, in the form: sxx.x
			
			Examples:
			    RSL=+10.0
			    RSL=-60.0
				N/A	RSL?	RSL=sxx.x
						(see description of arguments)

Rx Frequency Offset	N/A	5 bytes	Query only. Unit returns the value of the measured frequency offset of the carrier being demodulated. Values range from $\pm$ 0 to $\pm$ 30 kHz, 100 Hz resolution. Returns 99999 if the demodulator is unlocked. Example: RFO=+02.3 (which is + 2.3 kHz)	N/A	RFO?	RFO=xxxxx (see description of arguments)
Buffer Fill State	N/A	2 bytes	Query only. xx = value of the buffer fill state, between 1 to 99%. Returns 00 if demodulator is unlocked. Example: BFS=33 (which is 33%)	N/A	BFS?	BFS=xx (see description of arguments)
Rx BER	N/A	5 bytes	Query only. Unit returns the value of the estimated corrected BER in the form $a.b \times 10^{-c}$. First three bytes are the value. Last two bytes are the exponent. Returns 99999 if the demodulator is unlocked. Example: BER=4.8E3 (which is BER = 4.8×10^{-3})	N/A	BER?	BER=a.bEc (see description of arguments)

Parameter Type	Command (Instruction Code and Qualifier)	Arguments for Command or Response to Query	Description of Arguments	Response to Command	Query (Instruction Code and Qualifier)	Response to Query
Local/Remote Status	LRS=	1 byte, value of 0 or 1	Command or Query. Local/Remote status, where: 0=Local 1=Remote Example: LRS=1 (which is Remote)	LRS= LRS? LRS* LRS#	LRS?	LRS=x (see description of arguments)
Software Revision	N/A	43 bytes	Query only. Unit returns the value of the internal software revision installed in the unit, in the form: Boot:xx.yy.zz Bulk1:xx.yy.zz Bulk2:xx.yy.zz Example: SWR=Boot:01.01.01 Bulk1:01.01.01 Bulk2:01.01.01	N/A	SWR?	SWR=Boot:xx.yy.zz Bulk1:xx.yy.zz Bulk2:xx.yy.zz (see description of arguments)
Software Image	IMG=	1 bytes, value of 1 or 2	Command or Query. Current Active software image, where: 1 = Bulk Image #1 currently active 2 = Bulk Image #2 currently active Example: IMG=1 (which is Image #1 active)	IMG= IMG? IMG* IMG#	IMG?	IMG=x (see description of arguments)
Serial Number	N/A	9 bytes	Query only. Used to query the unit 9-digit serial number. Unit returns its S/N in the form xxxxxxxxx. Example: SNO=176500143	N/A	SNO?	SNO=xxxxxxxxx (see description of arguments)
Temperature	N/A	3 bytes	Query only. Unit returns the value of the internal temperature, in the form of xxx (degrees C). Example: TMP=+26	N/A	TMP?	TMP=xxx (see description of arguments)

Parameter Type	Command (Instruction Code and Qualifier)	Arguments for Command or Response to Query	Description of Arguments	Response to Command	Query (Instruction Code and Qualifier)	Response to Query
Equipment ID	N/A	17 bytes	Query only. Unit returns information concerning the equipment identification, and the option field, in the form aaaabcdefghijklxx; where: aaaa = defines the modem model number (5650 in this case) b = FEC Card #1: 0 = None, 1 = TPC c = FEC Card #2: 0 = None, 1 = TPC d = Option Card: 0 = None, 1 = G.703 e = Data Rate Option: 0 = Base (10,000 kbps), 1 = up to 20 kbps, 2 = up to 51840 kbps, 3 = up to 155,000 kbps, 4 = up to 200,000 kbps f = Higher-order modulation: 0 = None, 1 = 8PSK, 2 = 8PSK and 16QAM, 3 = 8PSK, 16QAM, and 64QAM g = Reed-Solomon Codec Option: 0 = None, 1 = Installed h = Asymmetrical Loop Timing Option: 0 = None, 1 = Installed i = AUPC Option: 0 = None, 1 = Installed j = IBS Overhead Option: 0 = None, 1 = Installed k = IDR Overhead Option: 0 = None, 1 = Installed l = Mil-165A Overhead Option: 0 = None, 1 = Installed x = spare Example: EID=56500000000000000 indicates SLM-5650 with no options installed	N/A	EID?	EID=aaaabcdefghijklxx (see description of arguments)

Parameter Type	Command (Instruction Code and Qualifier)	Arguments for Command or Response to Query	Description of Arguments	Response to Command	Query (Instruction Code and Qualifier)	Response to Query
Live Unit Faults	N/A	8 bytes	Query only. Live Unit Faults are returned as a 32 bit Hexadecimal value. Bit values are defined as follows: 80000000 = +5.0V Power 40000000 = +3.3V Power 20000000 = +2.5V Power 10000000 = +1.5V Power 08000000 = +12V Power 04000000 = -12V Power 02000000 = +18V Power 01000000 = Cooling Fan 00800000 = Ext Reference Activity 00400000 = 192 MHz Clock not locked 00200000 = 10 MHz Ref Clock not locked 00100000 = M&C FPGA not loaded 00080000 = Mod FPGA not loaded 00040000 = Demod FPGA not loaded 00020000 = Decoder FPGA not loaded 00010000 = Tx Interface FPGA not loaded 00008000 = Rx Interface FPGA not loaded 00004000 = FEC #1 FPGA not loaded 00002000 = FEC #2 FPGA not loaded 00001000 = Option Card FPGA not loaded Example: LUF=00000000 indicates No Unit Faults	N/A	LUF?	LUF=xxxxxxxx (see description of arguments)

Parameter Type	Command (Instruction Code and Qualifier)	Arguments for Command or Response to Query	Description of Arguments	Response to Command	Query (Instruction Code and Qualifier)	Response to Query
Live Tx Faults	N/A	8 bytes	Query only. Live Tx Faults are returned as a 32 bit Hexadecimal value. Bit values are defined as follows: 80000000 = Modulator Symbol Clock not locked 40000000 = Modulator RF Synthesizer not locked 20000000 = Modulator No IQ Activity 10000000 = Modulator Nyquist Filter Clipping 08000000 = Interface data clock PLLs not locked 04000000 = Interface Terrestrial Clock No Activity 02000000 = Interface SCT PLL not locked 01000000 = Interface No Data Activity Example: TXF=00000000 indicates No Tx Faults	N/A	TXF?	TXF=xxxxxxxx (see description of arguments)
Live Rx Faults	N/A	8 bytes	Query only. Live Rx Faults are returned as a 32 bit Hexadecimal value. Bit values are defined as follows: 80000000 = Demodulator IF not locked 40000000 = Demodulator Data Decoder not locked 20000000 = Demodulator RF Synthesizer not locked 10000000 = Demodulator No IQ Activity 08000000 = Interface De-Multiplexers not locked 04000000 = Interface Buffer Fault 02000000 = Interface Buffer about to slip 01000000 = Interface Buffer has overflowed 00800000 = Interface Buffer has underflowed 00400000 = Interface Buffer Clock PLL not locked 00200000 = Interface Buffer Clock Reference Activity 00100000 = Interface Data/AIS 00080000 = Eb/No Threshold exceeded Example: RXF=00000000 indicates No Rx Faults	N/A	RXF?	RXF=xxxxxxxx (see description of arguments)

Parameter Type	Command (Instruction Code and Qualifier)	Arguments for Command or Response to Query	Description of Arguments	Response to Command	Query (Instruction Code and Qualifier)	Response to Query
Number of Unread stored Events	N/A	3 bytes	Query only. Unit returns the Number of stored Events, which remain Unread, in the form xxx. Note: This means unread over the remote control. Example: NUE=126	N/A	NUE?	NUE=xxx (see description of arguments)
Initialize Events Pointer	IEP=	None	Command only. Resets internal pointer to allow RNE? queries to start at the beginning of the stored events log.	IEP= IEP#	N/A	N/A

Retrieve next 5 unread Stored Events	N/A	110 bytes	Query only.
			Unit returns the oldest 5 Stored Events, which have not yet been read over the remote control. Reply format: {CR}Sub-body{CR}Sub-body{CR}Sub-body{CR}Sub-body{CR}Sub-body, where Sub-body= Axxxxxxxxddmmyyhhmmss,
			A being the fault type where:
			  1=Unit
			  2=Rx Traffic
			  3=Tx Traffic
			  4=Info
			xxxxxxxx is the Fault Code number, as in LUF?, TXF?, RXF?, or Info Code, which is:
			  00000000=Power Off
			  00000001=Power On
			  00000002=Log Cleared
			  00000004=Global Config Change
			If there are less than 5 events to be retrieved, the remaining positions are padded with zeros.
			If there are no new events, the response is RNE*.
				N/A	RNE?	RNE={CR}Axxxxxxxxxddmmyyhhmmss{CR}Axxxxxxxxxddmmyyhhmmss{CR}Axxxxxxxxxddmmyyhhmmss{CR}Axxxxxxxxxddmmyyhhmmss{CR}Axxxxxxxxxddmmyyhhmmss
						(see description for details of arguments)

Clear All Stored Events	CAE=	None	Command only. Forces the software to clear the software events log. Example: CAE= Note: This command takes no arguments	CAE= CAE? CAE* CAE#	N/A	N/A

Parameter Type	Command (Instruction Code and Qualifier)	Arguments for Command or Response to Query	Description of Arguments	Response to Command	Query (Instruction Code and Qualifier)	Response to Query
Modem Alarm Mask	MSK=	6 bytes	Command or Query. Alarm mask conditions, in the form abcdef, where: a=spare (must be set to 0) b=spare (must be set to 0) c=spare (must be set to 0) d=spare (must be set to 0) e=spare (must be set to 0) f=Eb/No Threshold Alarm (0 = unmasked, 1 = masked) Example: MSK=000001	MSK= MSK? MSK* MSK#	MSK?	MSK=abcdef (see description of arguments)
Statistics Sample Interval	SSI=	1 byte	Command or Query. Used to set the sample interval for the Statistics Logging Function. SSI=x, where x = 0 to 9 in 10 minute steps. Note: Setting this parameter to 0 disables the statistics logging function. Example: SSI=3 sets the logging inverval to 30 minutes	SSI= SSI? SSI* SSI#	SSI?	SSI=x (see description of arguments)
Number of Unread stored Statistics	N/A	3 bytes	Query only. Unit returns the Number of stored Statistics, which remain Unread, in the form xxx. Note: This means unread over the remote control. Example: NUS=126	N/A	NUS?	NUS=xxx (see description of arguments)
Initialize Statistics Pointer	ISP=	None	Command only. Resets internal pointer to allow RNS? queries to start at the beginning of the stored statistics log.	ISP= ISP#	N/A	N/A

Parameter Type	Command (Instruction Code and Qualifier)	Arguments for Command or Response to Query	Description of Arguments	Response to Command	Query (Instruction Code and Qualifier)	Response to Query
Retrieve next 5 unread Stored Statistics	N/A	105 bytes	Query only. Unit returns the oldest 5 Stored Statistics, which have not yet been read over the remote control. Reply format: {CR}Sub-body{CR}Sub-body{CR}Sub-body{CR}Sub-body{CR}Sub-body, where Sub-body= AA.ABB.Bddmmyyhhmmss, AA.A = Minimum Eb/No during sample period. BB.B = Average Eb/No during sample period. If there are less than 5 events to be retrieved, the remaining positions are padded with zeros. If there are no new events, the response is RNS*.	N/A	RNS?	RNS={CR}AA.ABB.Bddmmyyhhmmss{CR}AA.ABB.Bddmmyyhhmmss{CR}AA.ABB.Bddmmyyhhmmss{CR}AA.ABB.Bddmmyyhhmmss{CR}AA.ABB.Bddmmyyhhmmss (see description for details of arguments)
Clear All Stored Statistics	CAS=	None	Command only. Forces the software to clear the software statistics log. Example: CAS= Note: This command takes no arguments	CAS= CAS? CAS* CAS#	N/A	N/A

G.703 Interface Card Remote Control Commands.
The following commands are only valid when the G.703 option card is installed in the SLM-5650 modem.

Parameter Type	Command (Instruction Code and Qualifier)	Arguments for Command or Response to Query	Description of Arguments	Response to Command	Query (Instruction Code and Qualifier)	Response to Query

Tx Ternary Code	TTC=	1 byte, value of 0 thru 3	Command or Query.
			
			Tx Ternary Code, where:
			  0=AMI
			  1=B8ZS
			  2=B6ZS
			  3=HDB3
			
			Example: TTC=3 (Set Tx Ternary Code to HDB3)
				TTC=
				TTC?
				TTC*
				TTC#
					TTC?	TTC=x
						(see description of arguments)

Rx Ternary Code	RTC=	1 byte, value of 0 thru 3	Command or Query.
			
			Rx Ternary Code, where:
			  0=AMI
			  1=B8ZS
			  2=B6ZS
			  3=HDB3
			
			Example: RTC=3 (Set Rx Ternary Code to HDB3)
				RTC=
				RTC?
				RTC*
				RTC#
					RTC?	RTC=x
						(see description of arguments)

Receive T1 Framing	T1F=	1 byte, value of 0 or 1	Command or Query.
			
			Receive T1 Framing, where:
			  0=None
			  1=G.704
			
			Example: T1F=0
				T1F=
				T1F?
				T1F*
				T1F#
					T1F?	T1F=x
						(see description of arguments)

Receive E1 Framing	E1F=	1 byte, value of 0 or 1	Command or Query.
			
			Receive T1 Framing, where:
			  0=None
			  1=G.704
			
			Example: E1F=0
				E1F=
				E1F?
				E1F*
				E1F#
					E1F?	E1F=x
						(see description of arguments)

Parameter Type	Command (Instruction Code and Qualifier)	Arguments for Command or Response to Query	Description of Arguments	Response to Command	Query (Instruction Code and Qualifier)	Response to Query

Receive T2 Framing	T2F=	1 byte, value of 0, 1, 3, or 5	Command or Query.
			
			Receive T2 Framing, where:
			   0=None
			   1=G.704
			   3=G.743
			   5=G.747
			
			Example: T2F=0
				T2F=
				T2F?
				T2F*
				T2F#
					T2F?	T2F=x
						(see description of arguments)

Receive E2 Framing	E2F=	1 byte, value of 0, 1, 2, or 4	Command or Query.
			
			Receive E2 Framing, where:
			   0=None
			   1=G.704
			   2=G.742
			   4=G.745
			
			Example: E2F=0
				E2F=
				E2F?
				E2F*
				E2F#
					E2F?	E2F=x
						(see description of arguments)

External Buffer Clock Reference	ERF=	1 byte, value of 0 thru 3	Command or Query.
			
			External Buffer Clock Reference, where:
			   0=External Clock equals Rx Data Rate
			   1=5 MHz External Clock
			   2=10 MHz External Clock
			   3=20 MHz External Clock
			
			Example: ERF=0
				ERF=
				ERF?
				ERF*
				ERF#
					ERF?	ERF=x
						(see description of arguments)

Automatic Uplink Power Control (AUPC) Remote Control Commands.
The following commands are only valid when the SLM-5650 modem type has been set to AUPC. Note: Always wait 3 seconds between consecutive remote modem command/query polls. If Local AUPC is not enabled, query commands will return the last known condition. A request for status from the remote modem will then be transmitted, ensuring that the next query will return current status.

Parameter Type	Command (Instruction Code and Qualifier)	Arguments for Command or Response to Query	Description of Arguments	Response to Command	Query (Instruction Code and Qualifier)	Response to Query

AUPC Local Enable	LPC=	1 byte, value of 0 or 1	Command or Query.
			
			Local AUPC Control, where:
			    0=Off
			    1=On
			
			NOTE: When Local AUPC Control is enabled, modulator output power is automatically controlled by the modem. Power output commands via TPL are not allowed during this mode; although, queries will function as normal.
			
			Example: LPC=1 (Turn on Local AUPC Control)
				LPC=
				LPC?
				LPC*
				LPC#
					LPC?	LPC=x
						(see description of arguments)

AUPC Nominal Power Level	ANP=	5 bytes	Command or Query. Nominal Tx Output power level, where: s=sign (+ / -) xx.x = Tx Output power level, +10.0 and –40.0 dBm. Example: ANP=-13.4	ANP= ANP? ANP* ANP#	ANP?	ANP=sxx.x (see description of arguments)
AUPC Maximum Power Level	AMX=	5 bytes	Command or Query. Maximum Tx Output power level, where: s=sign (+ / -) xx.x = Tx Output power level, +10.0 and –40.0 dBm. Example: AMX=-13.4	AMX= AMX? AMX* AMX#	AMX?	AMX=sxx.x (see description of arguments)

Parameter Type	Command (Instruction Code and Qualifier)	Arguments for Command or Response to Query	Description of Arguments	Response to Command	Query (Instruction Code and Qualifier)	Response to Query
AUPC Minimum Power Level	AMN=	5 bytes	Command or Query. Minimum Tx Output power level, where: s=sign (+ / -) xx.x = Tx Output power level, +10.0 and –40.0 dBm. Example: AMN=-13.4	AMN= AMN? AMN* AMN#	AMN?	AMN=sxx.x (see description of arguments)
AUPC Eb/N0 Target Set Point	AET=	4 bytes	Command or Query. AUPC Eb/N0 Target, where: xx.x = AUPC Eb/N0 Target, 3.2 to 16.0 dB. Example: AET=13.4	AET= AET? AET* AET#	AET?	AET=xx.x (see description of arguments)
AUPC Maximum Tracking Rate	AMT=	3 bytes	Command or Query. AUPC Maximum Tracking Rate, where: x.x = Maximum Tracking Rate, 0.5 to 6.0 dBm/minute in increments of .5. Example: AMT=0.5	AMT= AMT? AMT* AMT#	AMT?	AMT=x.x (see description of arguments)

AUPC Local Carrier Loss Action	LCL=	1 byte, values of 0 thru 2	Command or Query.
			
			Tx Output Power level setting when local carrier is lost, where:
			    0=Hold current output power level
			    1=Goto Nominal output power level
			    2=Goto Maximum output power level
			
			Example: LCL=0
				LCL=
				LCL?
				LCL*
				LCL#
					LCL?	LCL=x
						(see description of arguments)

AUPC Remote Carrier Loss Action	RCL=	1 byte, values of 0 thru 2	Command or Query.
			
			Tx Output Power level setting when remote carrier is lost, where:
			    0=Hold current output power level
			    1=Goto Nominal output power level
			    2=Goto Maximum output power level
			
			Example: RCL=0
				RCL=
				RCL?
				RCL*
				RCL#
					RCL?	RCL=x
						(see description of arguments)

Parameter Type	Command (Instruction Code and Qualifier)	Arguments for Command or Response to Query	Description of Arguments	Response to Command	Query (Instruction Code and Qualifier)	Response to Query

Remote Modem AUPC Enable	RPC=	1 byte, values of 0 or 1	Command or Query.
			
			Remote Modem AUPC Control, where:
			  0=Off
			  1=On
			
			Example: RPC=1 (Turn on remote modem AUPC Control)
				RPC=
				RPC?
				RPC*
				RPC#
					RPC?	RPC=x
						(see description of arguments)

Remote Modem Pattern Substitution	RPB=	1 byte, values of 0 or 1	Command or Query.
			
			Remote Modem Tx Pattern Substitution, where:
			  0=Off
			  1=On
			
			NOTE: For compatibility reasons, only the 2047 Tx pattern can be turned On or Off at the remote modem..
			
			Example: RPB=1 (Turn on remote modem AUPC Control)
				RPB=
				RPB?
				RPB*
				RPB#
					RPB?	RPB=x
						(see description of arguments)

Remote Modem I/O Loopback	RPL=	1 byte, values of 0 or 1	Command or Query.
			
			Remote Modem I/O Loopback Mode, where:
			  0=Off
			  1=On
			
			Example: RPL=1 (Turn on remote modem AUPC Control)
				RPL=
				RPL?
				RPL*
				RPL#
					RPL?	RPL=x
						(see description of arguments)

Remote Modem BERT BER	N/A	6 bytes	Query only. Unit returns the value of the remote modem's BERT BER in the form a.b x 10^{-c}. First three bytes are the value. Last two bytes are the exponent. Returns 0.0E00 if the BERT is not synchronized to a pattern. Example: RPE=4.0E06	N/A	RPE?	RPE=a.bEcc (see description of arguments)

Parameter Type	Command (Instruction Code and Qualifier)	Arguments for Command or Response to Query	Description of Arguments	Response to Command	Query (Instruction Code and Qualifier)	Response to Query
Global Configuration	MGC=	177 bytes, with numerical entries, fixed values and delimiters	Command or Query. Global Configuration of SLM-5650, in the form: abcdeeeeeefghijkkkkkkkklmnoooooo.oooppppp.ppppqrrrstuvwxyyy. yzABCDEFGHHHHHHHHIJKLLLLLLL.LLLMMMM.MMMMN OOOPQRSTUVWXYZZZZ.ZZZAAABCDDDDDDDDEE.EFGH IJKLMNNN.NOOO.OPPP.PQQ.QR.RSTUUUUUUUU where: a = Modem Operating Mode same as MOM b = Modem RF Band same as RFB c = Modem Interface Type same as ITF d = Modem Reference Clock same as MRC eeeee = Modem Alarm Mask same as MSK f = Carrier Only Test Modes same as COM g = Loopback Test Modes same as LOP h = Tx BERT State same as BTX i = Rx BERT State same as BRX j = BERT Pattern same as PAT kkkkkkkk = expansion bytes l = Tx FEC Type same as TFT m = Tx Modulation Type same as TMD n = Tx Code Rate same as TCR oooooo.ooo = Tx Data Rate same as TDR pppp.pppp = Tx Frequency same as TFQ q = Tx Overhead Type same as TFM rrr = Reserved s = Tx Reed-Solomon state same as TRS t = Tx Reed-Solomon code word same as TCW u = Tx Reed-Solomon interleaver depth same as TRD v = Tx Spectrum Invert same as TSI w = Tx Scrambler same as TSC x = Tx Differential Encoder same as TDE yyy.y = Tx Power Level same as TPL z = Tx Clock Source same as TCK	MGC= MGC? MGC* MGC#	MGC?	MGC=abcdeeeeeefghijk kkkkkkkklmnoooooo.ooo ppppp.ppppqrrrstuvwxyy y.yzABCDEFGHHHHH HHHIJKLLLLLLL.LLL MMMM.MMMMNOO OPQRSTUVWXYZZZZ .ZZZAAABCDDDDDD DDEE.EFGHIJKLMNN N.NOOO.OPPP.PQQ.Q R.RSTUUUUUUUU (see description of arguments)

Parameter Type	Command (Instruction Code and Qualifier)	Arguments for Command or Response to Query	Description of Arguments	Response to Command	Query (Instruction Code and Qualifier)	Response to Query
			A = Tx SCT Reference same as SCT B = Tx Clock Invert same as TCI C = Tx Data Invert same as TDI D = Tx Data Fault same as TDF E = Tx BPSK Data Ordering same as TBO F = Tx Carrier State same as TXO G = Tx Ternary Code same as TTC HHHHHHHH = expansion bytes I = Rx FEC Type same as RFT J = Rx Modulation Type same as RMD K = Rx Code Rate same as RCR LLLLLL.LLL = Rx Data Rate same as RDR MMMM.MMMM = Rx Frequency same as RFQ N = Rx Overhead Type same as RFM OOO = Reserved P = Rx Reed-Solomon state same as RRS Q = Rx Reed-Solomon code word same as RCW R = Rx Reed-Solomon interleaver depth same as RRD S = Rx Spectrum Invert same as RSI T = Rx Descrambler same as RDS U = Rx Differential Decoder same as RDD V = Rx Clock Invert same as RCI W = Rx Data Invert same as RDI X = Rx Data Fault same as RDF Y = Rx BPSK Data Ordering same as RBO ZZZZ.ZZZ = Rx Demod Acq Sweep Range same as RSW AAA = Rx Reacquisition Time same as REA B = Rx Clock Source same as RCK C = Rx Buffer Programming Mode same as RBM DDDDDDDD = Rx Buffer Size same as RBS EE.E = Eb/No Alarm Point same as EBA F = Statistics Sample Interval same as SSI G = Rx Ternary Code same as RTC H = Receive T1 Framing same as T1F I = Receive E1 Framing same as E1F			

Parameter Type	Command (Instruction Code and Qualifier)	Arguments for Command or Response to Query	Description of Arguments	Response to Command	Query (Instruction Code and Qualifier)	Response to Query
			J = Receive T2 Framing same as T2F K = Receive E2 Framing same as E2F L = External Buffer Clock Reference same as ERF M = AUPC Local Enable same as LPC NNN.N = AUPC Nominal Power Level same as ANP OOO.O = AUPC Maximum Power Level same as AMX PPP.P = AUPC Minimum Power Level same as AMN QQ.Q = AUPC Eb/No Target Level same as AET R.R = AUPC Max Tracking Rate same as AMT S = AUPC Local Carrier Loss Action same as LCL T = AUPC Local Carrier Loss Action same as RCL UUUUUUUU = expansion bytes Fill unused expansion bytes with 'x'			

Note: The following codes are used in the 'Response to Command' column:

=   Message ok
?   Received ok, but invalid arguments found
*   Message ok, but not permitted in current mode
#   Message ok, but unit is not in **Remote** mode

This page is intentionally left blank.

Appendix C. FLASH UPGRADING

The SLM-5650 eliminates the need for updating firmware by physically replacing EPROMs. Instead, the SLM-5650 modem uses 'flash memory' technology internally, and new firmware can be uploaded to the unit from an external PC, as follows:

- Go to: www.comtechefdata.com
- Click on: downloads
- Click on: flash upgrades

This makes software upgrading very simple, and updates can now be sent via the Internet, E-mail, or on disk. The upgrade can be performed without opening the unit, by simply connecting the modem to the Ethernet port of a computer.

C.1   Ethernet FTP upload procedure:

1. Identify the reflashable product, firmware number, and version for download.

    The current base modem M&C version can be viewed at the top-level menu of the front panel display (press "CLR" button several times to view). Also, you can find the firmware information within the <Util > <Firmware > <Info> <Image#1, Image#2 > menu tree.

    Using serial remote control, you can query the firmware revision levels with the <0/SWR? Command. (Abbreviated)
          Or
    <)/FRW? Command (Detailed)

2. Create a temporary directory (folder) on your PC.

   Windows: Select File > New > Folder > and rename the New Folder to "temp" or
   another convenient and unused name. Assuming "temp" works, you should now
   have a "c:\temp" folder created.

   Note: The c: is the drive letter used in this example. Any valid writable drive letter
   can be used.

   Alternative Method: CMD Prompt: At the command prompt (c:\>) type "MD temp"
   without quotes (MD stands for make directory). This is the same as creating a new
   folder from Windows. You should now have a "c:\temp" subdirectory created where
   c: is the drive letter used in the example.

3. Download the correct firmware file to this temporary folder.

   Access the download server with the flash firmware data files link,
   http://206.223.8.10/linksite/flashupgrades/SLM-5650/

   About Firmware Numbers, File Versions, and Formats:

   The flashable files on the download server are organized by product first, then by
   firmware number, (make sure you know the correct firmware number; see step 1)
   version, if applicable, and release date. The base modem bulk firmware for the SLM-
   5650 will be **FW11188***_*_* (where the asterisks show revision, version and date).

   The current version firmware release is provided. If applicable, one version prior to
   the current release is also available. Be sure to identify and download the desired
   version.

   The downloadable files are stored in two formats: *.exe (self extracting) and *.zip
   (compressed). Some firewalls will not allow the downloading of *.exe files. In this
   case, download the *.zip file instead.

   For additional help with "zipped" file types, refer to "pkzip for windows", "winzip",
   or "zip central" help files. Pkzip for DOS is not supported due to file naming
   conventions.

4. Unzip the files in the temporary folder on your PC.

   At least 3 files should be extracted:

   a. **FW11188**x.bin, where "x" is the version (bulk image file).
   b. **FW11188**x.txt, where "x" is the version (history notes).
   c. README.TXT installation notes

5. Connect the client PC to the SLM-5650 modem 10/100 Ethernet M&C via a hub or a
   switch, or directly to a PC with a crossover cable.

Verify the communication and connection by issuing a "ping" command to the modem. You can find the IP address of the modem either remotely using the <0/IPA? command or from the front panel with the <Config> <Remote> <Remote> <Ethernet> menus.

To PING and FTP from DOS, press the "Start" button on the Windows toolbar, and select the "Run..." option. From Win95 or Win98, type, "command". From WinNT, Win2K or WinXP, type "cmd". You can also use the "DOS Prompt" or "Command Prompt" icons in the Start Menu. Now change to the temporary directory you created earlier with "cd c:\temp". A quick "dir" will show the downloaded files.

6. Initiate an FTP session with the modem. The example is with a DOS window.

    a. From the PC, type "ftp xxx.xxx.xxx.xxx" where "xxx.xxx.xxx.xxx" is the IP address of the SLM-5650.

    b. Enter your admin user name and password to complete login.
           Factory Default user is: COMTECH
           Password is: COMTECH

    c. Verify your FTP transfer is binary by typing, "bin".

    d. Type "prompt" then type "hash" to facilitate the file transfers.

7. Transfer the files.

    Type "put **FW11188***.bin bulk:" to begin the file transfers. The destination "bulk:" must be all lower-case. It will take approximately one minute to transfer the file.

8. Verify the file transfer.

    a. The PC should report that the file transfer has occurred, and the display on the modem will start reporting "PROGRAMMING FLASH SECTOR # xx – PLEASE WAIT".

    b. Terminate the FTP session by typing "bye" and closing the DOS window.

    c. Verify that the new file loaded using the procedure in step 1.

9. Change the desired image to boot using the <Util> <Firmware> <Select> <left or right arrow to change to the other image>, then cycle power to reboot the modem.

10. Verify the new software versions are booting by observing the following messages on the modem display:

```
Comtech SLM-5650 Modem
Firmware Version: 1.1.x
```

Appendix D. ETHERNET MANAGEMENT

D.1 Introduction

The base modem is equipped with an RJ-45, 10/100BaseT Ethernet management interface used for monitor and control purposes.

This chapter of the manual will provide a high-level overview of the functionality provided by this interface and references other chapters for further details.

D.2 Ethernet Management Interface Protocols

The modem 10/100BaseT Ethernet Management Interface supports three (3) different management protocols:

- Web Server interface for complete product management
- SNMP with public and private MIB
- Telnet interface for remote product M&C

In general, the operation of each of these interfaces is essentially identical to the management interfaces that are available when the optional IP module is installed.

D.3   Web Server (HTTP) Interface

The embedded Web Server application provides the user with an easy to use interface to configure and monitor all aspects of the Base Modem. These web pages have been designed for optimal performance when using Microsoft's Internet Explorer 5.5 or higher. By typing http://xxx.xxx.xxx.xxx" (where xxx.xxx.xxx.xxx =Base Modem IP address) on your browser, the Login prompt will appear.
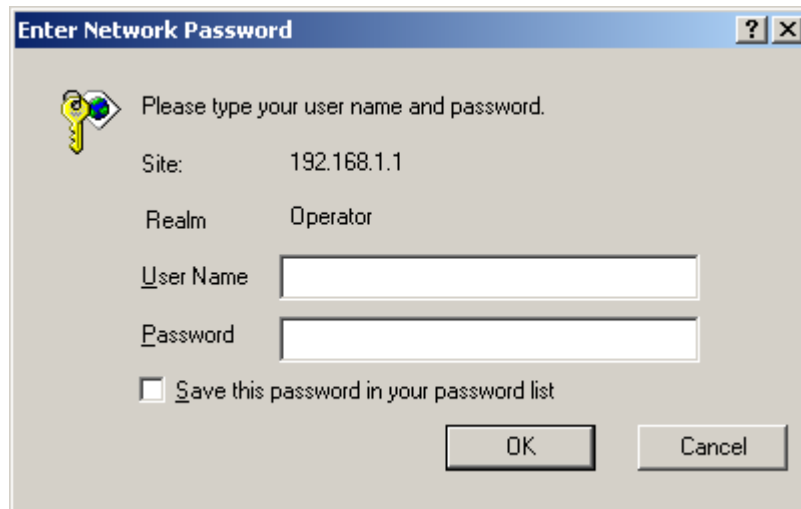
HTTP Login Access Levels are defined as follows:

User Interface	User Login Access Level		
	Admin User	**Read/Write User**	**Read Only User**
Web	FULL ACCESS TO ALL WEB PAGES	NO ACCESS TO ADMIN PAGES	NO ACCESS TO ADMIN PAGES
		FULL ACCESS FOR ALL OTHER WEB PAGES	VIEW ONLY ACCESS FOR ALL OTHER WEB PAGES

Default Name/Passwords are:

- Admin   comtech/comtech
- Read/Write   opcenter/1234
- Read Only   monitor/1234

D.4   Web Server Menu Tree

Table D-1. Web Server Menu Tree

Level 1	Level 2
Home	Home
	Contact
	Support
Admin	Access
	Remote
Config Mdm	Page 1
	Page 2
	AUPC
Stats	Modem Status
	Modem Logs
ODU (CDM-570 only)	Config
	Status
	Utilities
Maint	Unit Info

D.5 SNMP Interface

The *Simple Network Management Protocol* (SNMP) is an application-layer protocol designed to facilitate the exchange of management information between network devices. The SLM-5650 SNMP agent supports both SNMPv1 and v2c.

> **!** **IMPORTANT** **For proper SNMP operation, the SLM-5650 MIB files must be used with the associated version of the SLM-5650 base modem M&C. Please refer to the SLM-5650 SW Release Notes for information on the required FW/SW compatibility.**

D.5.1 Management Information Base (MIB) Files

MIB files are used for SNMP remote management and consist of Object Identifiers (OID's). Each OID is a node that provides remote management of a particular function. A MIB file is a tree of nodes that is unique to a particular device.

There are three MIB files associated with the SLM-5650:

MIB File/Name	Description

fw10874-2-.mib ComtechEFData MIB file	**ComtechEFData MIB file gives the root tree for ALL Comtech EF Data products and consists of only the following OID:**
	  Name: comtechEFData
	  Type: MODULE-IDENTITY
	  OID: 1.3.6.1.4.1.6247
	  Full
	  path: iso(1).org(3).dod(6).internet(1).private(4).enterprises(1).comtechEFData(6247)
	  Module: ComtechEFData

FW/11187-4D SLM-5650	**MIB file consists of all of the OID's for management of the modem functions**
FW/11187-5A SLM-5650 Traps MIB file	**Trap MIB file is provided for SNMPv1 traps common for base modems.**

These MIB files should be compiled in a MIB Browser or SNMP Network Monitoring System server.

Note: The SNMP agent supports both "**SNMPv1"** and "**v2c"**. The "**Traps"** file only needs to be compiled if "**SNMPv1"** traps are to be used.

D.5.2   SNMP Community Strings

The modem uses community strings as a password scheme that provides authentication before gaining access to the modem agent's MIBs.

In "**SNMP v1/v2c**", the community string is sent unencrypted in the SNMP packets. Caution must be taken by the network administrator to ensure that SNMP packets travel only over a secure and private network if security is a concern. A packet sniffer can easily obtain the community string by viewing the SNMP traffic on the network.

The community string is entered into the MIB Browser or Network Node Management software and is used to authenticate users and determine access privileges to the SNMP agent.

The user defines three Community Strings for SNMP access:

- Read Community   default = public
- Write Community   default = private
- Trap Community   default = comtech

Note: Maximum number of characters for community strings shall not exceed 20. All printable ASCII characters, except '\' and '~' are allowed. No trailing spaces for community strings.

D.5.3   SNMP Traps

The modem has the ability to send out SNMP traps when certain events occur in the modem. The modem sends out traps when an alarm or a fault occurs in the modem. These include unit faults, TX faults, and RX faults. A trap is sent both when a fault occurs and is cleared.

The modem supports both **SNMPv1** traps and **SNMPv2** notifications. Which style of traps the modem sends can be configured by the user using the slm5650SNMPTrapVersion OID.

The following are the MIB2 v1traps/v2 notifications that the modem supports:

MIB2 SNMPv1 trap: Authentication Failure   5

MIB2 SNMPv2 notifications: Authentication Failure   1.3.6.1.6.3.1.1.5.5

The following tables are the Alarms and Faults v1 traps / v2 notifications that the modem supports.

Alarms and Faults **SNMPv1** traps:

slm5650TxTrafficAlarmV1	6247282
slm5650UnitAlarmV1	6247281
slm5650RedundancyStateV1	6247283
slm5650RedundancyStateV1	6247284

Alarms and Faults **SNMPv2** notifications:

slm5650UnitAlarmV2	1.3.6.1.4.1.6247.28.2.1.1.
slm5650TxTrafficAlarmV2	1.3.6.1.4.1.6247.28.2.1.2
slm5650RxTrafficAlarmV2	1.3.6.1.4.1.6247.28.2.1.3
slm5650RedundancyStateV2	1.3.6.1.4.1.6247.28.2.1.4
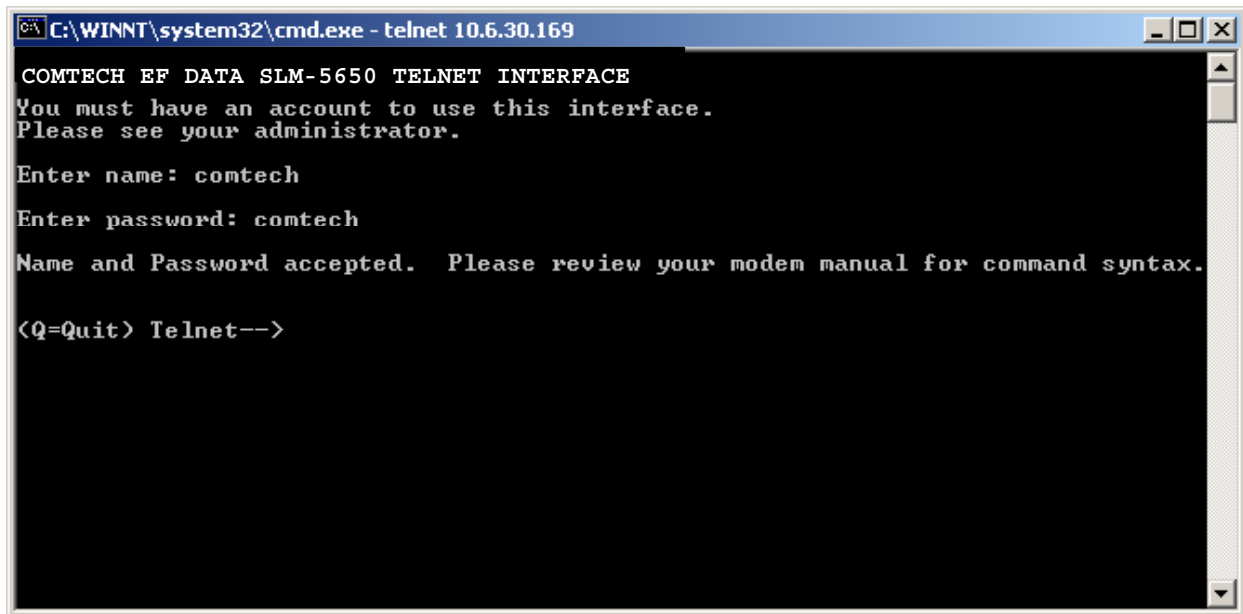
Telnet Interface

The modem provides a Telnet interface for two primary functions:

- Equipment M&C via the standard equipment Remote Control protocol.
- Equipment M&C via Comtech Monitor and Control System (CMCS) application.
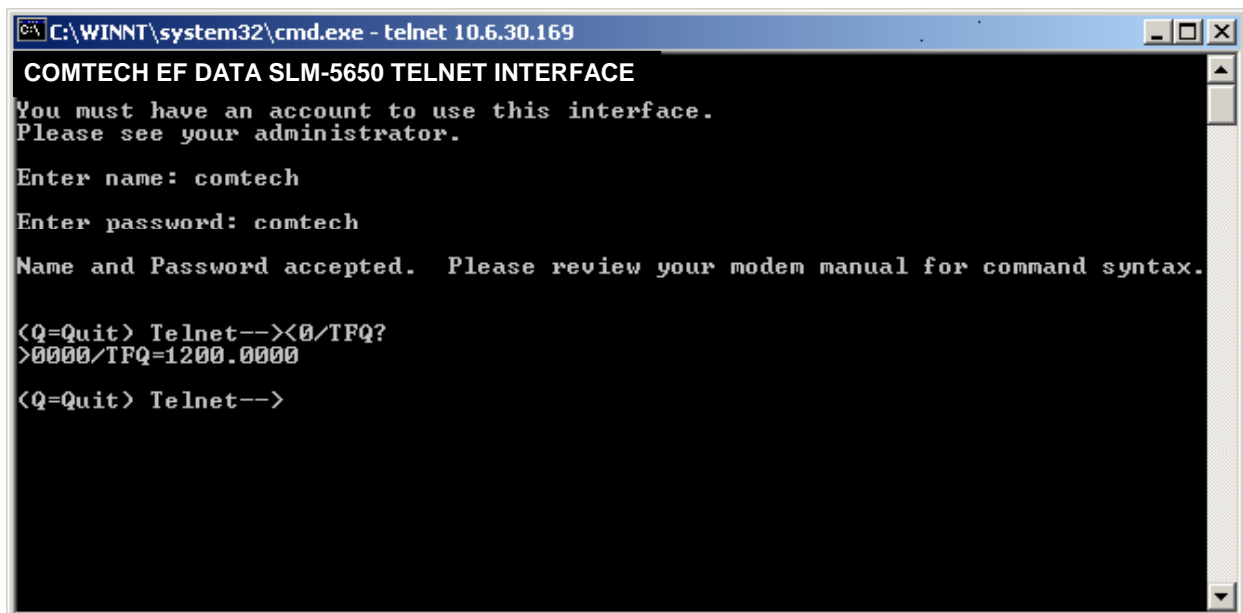
The Telnet interface requires user login at the **Administrator** level and **Read/Write** level.

The screen capture below shows the login process :

```
C:\WINNT\system32\cmd.exe - telnet 10.6.30.169                                    _ □ ×

 COMTECH EF DATA SLM-5650 TELNET INTERFACE
You must have an account to use this interface.
Please see your administrator.

Enter name: comtech

Enter password: comtech

Name and Password accepted.  Please review your modem manual for command syntax.


<Q=Quit> Telnet-->
```

Once logged into the Telnet interface as the Administrator, the user can access the standard remote control interface defined in Chapter 13 as shown in the example below:

```
C:\WINNT\system32\cmd.exe - telnet 10.6.30.169                                    _ □ ×

 COMTECH EF DATA SLM-5650 TELNET INTERFACE
You must have an account to use this interface.
Please see your administrator.

Enter name: comtech

Enter password: comtech

Name and Password accepted.  Please review your modem manual for command syntax.


<Q=Quit> Telnet--><0/TFQ?
>0000/TFQ=1200.0000

<Q=Quit> Telnet-->
```

There is a disadvantage when using Windows DOS as Telnet Client. Since Windows DOS cannot translate a '\r' to a '\r\n' for the messages coming from Telnet Server, the multi-line command response (for example, FRW? response) will be displayed as one line, with the latter lines overwriting the previous lines.
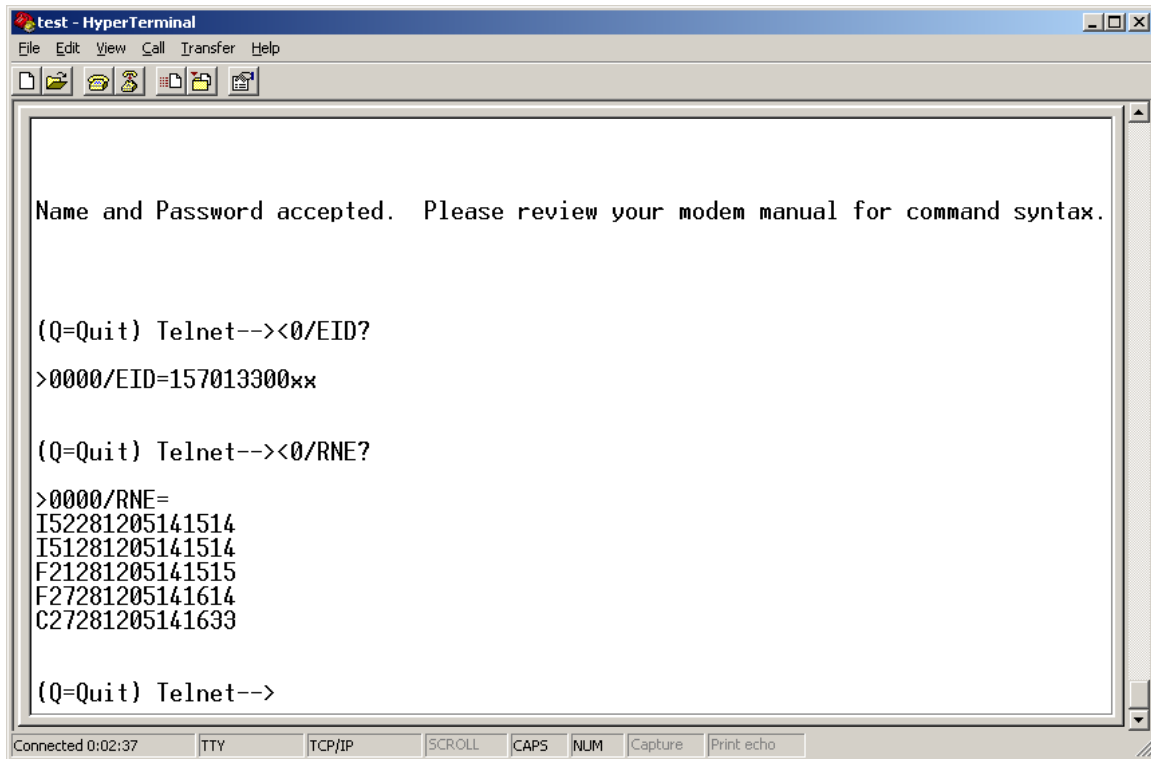
In order to view the full response messages, CEFD recommends using HyperTerminal configured as Telnet Client. To do so, configure the HyperTerminal as following:

1. Connect using TCP/IP instead of COM1 or COM2;
2. ASCII setup: check both the "Send line ends with line feeds" and "Append line feeds to incoming line ends" options.

See the following screen captures for examples.

ASCII Setup

ASCII Sending
- ☑ Send line ends with line feeds
- ☐ Echo typed characters locally

Line delay: 0 milliseconds.

Character delay: 0 milliseconds.

ASCII Receiving
- ☑ Append line feeds to incoming line ends
- ☐ Force incoming data to 7-bit ASCII
- ☑ Wrap lines that exceed terminal width

OK   Cancel

---

test - HyperTerminal
File Edit View Call Transfer Help

```
COMTECH EF DATA SLM-5650 TELNET INTERFACE


You must have an account to use this interface.
Please see your administrator.


Enter name: comtech


Enter password: comtech


Name and Password accepted.  Please review your modem manual for command syntax.


(Q=Quit) Telnet-->
```

Connected 0:00:40   TTY   TCP/IP   SCROLL   CAPS   NUM   Capture   Print echo

```
test - HyperTerminal                                                    _ □ ×
File  Edit  View  Call  Transfer  Help

Name and Password accepted.  Please review your modem manual for command syntax.


(Q=Quit) Telnet-->0/EID?

>0000/EID=157013300xx


(Q=Quit) Telnet-->0/RNE?

>0000/RNE=
I52281205141514
I51281205141514
F21281205141515
F27281205141614
C27281205141633


(Q=Quit) Telnet-->

Connected 0:02:37      TTY        TCP/IP      SCROLL   CAPS   NUM   Capture   Print echo
```

Appendix E. 10/100/1000 Base-T (GbE) Interface

E.1   Introduction

The 1000 Base-T Ethernet Interface or GbE acts as an Ethernet bridge for data traffic. The GbE Interface is shown in Figure E-1. **M**onitor and **C**ontrol (M&C) information is not supported on the GbE Interface but is available through the 10/100 Base-T remote port of the modem. The GbE Interface is 10/100/1000 Base-T and supports data rates from 1 Mbps to 155 Mbps. IP traffic entering the GbE Interface is encapsulated in HDLC protocol for transmission over the satellite link. HDLC CRS-16 verification is performed on all received (from WAN) HDLC frames. The user interface to the GbE card is a single IEEE 802.3ab 1000 Base-T copper compliant female RJ-45 connector wired as described in Table E-1.

Figure E-1. 10/100/1000 Base-T Ethernet (GbE) Interface

E.2   Physical Description

The GbE is implemented on a 4.5 W x 6.8 D x .85 H inches (11.43 W x 17.27 D x 2.16H cm)
PCB. Connectivity to the SLM-5650 will be implemented with a 96-pin DIN receptacle, and the
LAN interface consists of an RJ-45 connector with link status and link activity Light-Emitting
Diode (LED) indicators (at minimum).

E.3   General Specifications

Table E-1. Interface Specifications

General Specifications	
Data Framing	10/100/1000 Base-T Interface: RFC-894 "Ethernet"
Data Framing Format (WAN)	HDLC (Standard Single Channel)
Connector	RJ-45 female, 100Ω
Electrical Properties	Per IEEE 802.3ab
Packet Types	Burst, distributed, or IPV4
Signal Types	Serial data
Voltage Level	Per IEEE- 802.3ab
Packet Latency	50 ms maximum
Flow Control	None
Cable Length, Maximum	100 meters CAT 5 cable, patch cords and connecting hardware, per ISO/IEC 11801:1995 and ANSI/EIA/TIA-568-A (1995)
Hot Pluggable (cable)	Yes
Hot Pluggable (card)	NO
LEDs	Link Status, link activity

Ingress Packet Filtration Parameters	MAC, IP address match value configuration for media and management packets, UDP port for media packets
Egress Packet Parameters	Destination IP address and UDP port for media packets
Packet Filtration Parameters (generic)	IP address match value configuration for management packets
1000Base-T Link Statistics	Ingress good octets Ingress bad octets Ingress unicast packets Ingress broadcast packets Ingress multicast packets Ingress pause packets Ingress undersize packets Ingress fragments Ingress oversize packets Ingress jabber

Monitor & Control	
	Ingress Rx errors
	Ingress Frame Check Sequence Errors
	Egress oclets
	Egress unicast packets
	Egress broadcast packets
	Egress multicast packets
WAN Port Statistics	Ingress good oclets
	Ingress bad oclets
	Ingress unicast packets
	Ingress broadcast packets
	Ingress multicast packets
	Ingress pause packets
	Ingress undersize packets
	Ingress fragments
	Ingress oversize packets
	Ingress jabber
	Ingress Rx errors
	Ingress Frame Check Sequence Errors
	Egress oclets
	Egress unicast packets
	Egress broadcast packets
	Egress multicast packets
	HDLC link errors
	Rx packet count
	Tx packet count
Management Port Statistics	Ingress good oclets
	Ingress bad oclets
	Ingress unicast packets
	Ingress broadcast packets
	Ingress multicast packets
	Ingress pause packets
	Ingress undersize packets
	Ingress fragments
	Ingress oversize packets
	Ingress jabber
	Ingress Rx errors
	Ingress Frame Check Sequence Errors
	Egress oclets
	Egress unicast packets
	Egress broadcast packets
	Egress multicast packets
Controlled Functions	TX data rate
	Rx data rate
	Tx enable/disable
	Rx enable/disable
	Management IP Address and Mask
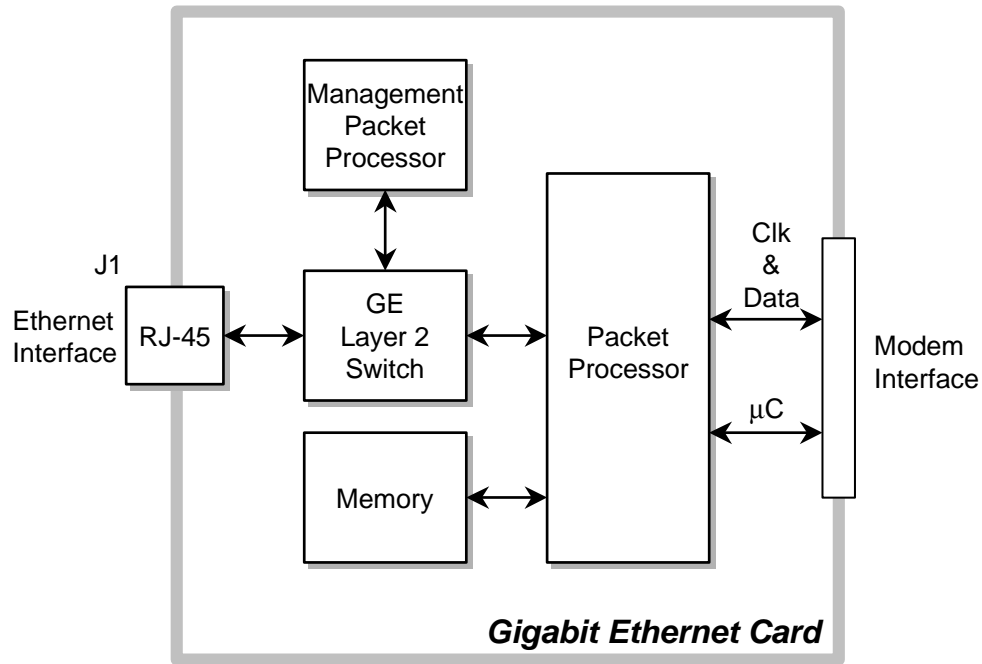
Figure E-2. GbE Interface Option Board

E.4   Connector Pinout

The LAN interface is comprised of one IEEE 802.3ab 1000Base-T copper interface via a single female RJ-45 connector wired:

Table E-2. Connector Pinout

Pin #	Description	Direction
1	BI_DA+	bidirectional
2	BI_DA-	bidirectional
3	BI_DB+	bidirectional
4	BI_DC+	bidirectional
5	BI_DC-	bidirectional
6	BI_DB-	bidirectional
7	BI_DD+	bidirectional
8	BI_DD-	bidirectional

E.5   1000 Base-T Ethernet (GbE) Interface Card Removal and   Installation

⚠ WARNING

Ensure the unit is in a Power Off mode. Serious injury or damage to the equipment could result. The card plugs in upside down.
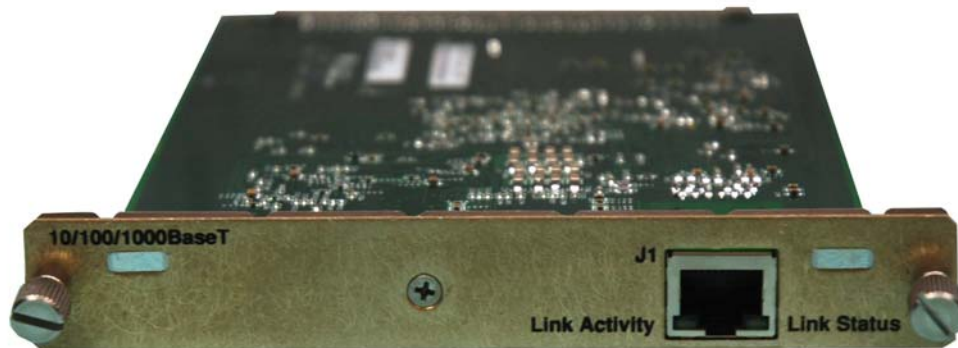
Figure E-3. 1000 Base-T Ethernet (GbE) Interface Card

Removal of the Interface Card:

Steps	Procedures
1	Turn power to the modem off.
2	Disconnect the RJ-45 cable from the interface card.
3	Remove the two screws securing the interface card.
4	Pull out the interface card.

Installation of the Interface Card:

Steps	Procedures
1	Insert the Interface Card into the slot.
2	Ensure that the interface card is secured to the internal card.
3	Secure the interface using the two capture screws.
4	Connect the RJ-45 cable to the interface card.
5	Turn power to the modem on.

This page is intentionally left blank.

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METRIC CONVERSIONS

Units of Length

Unit	Centimeter	Inch	Foot	Yard	Mile	Meter	Kilometer	Millimeter
1 centimeter	—	0.3937	0.03281	0.01094	6.214×10^{-6}	0.01	—	—
1 inch	2.540	—	0.08333	0.2778	1.578×10^{-5}	0.254	—	25.4
1 foot	30.480	12.0	—	0.3333	1.893×10^{-4}	0.3048	—	—
1 yard	91.44	36.0	3.0	—	5.679×10^{-4}	0.9144	—	—
1 meter	100.0	39.37	3.281	1.094	6.214×10^{-4}	—	—	—
1 mile	1.609×10^5	6.336×10^4	5.280×10^3	1.760×10^3	—	1.609×10^3	1.609	—
1 mm	—	0.03937	—	—	—	—	—	—
1 kilometer	—	—	—	—	0.621	—	—	—

Temperature Conversions

Unit	° Fahrenheit	° Centigrade
32° Fahrenheit	—	0 (water freezes)
212° Fahrenheit	—	100 (water boils)
-459.6° Fahrenheit	—	273.1 (absolute 0)

Formulas
C = (F - 32) * 0.555
F = (C * 1.8) + 32

Units of Weight

Unit	Gram	Ounce Avoirdupois	Ounce Troy	Pound Avoir.	Pound Troy	Kilogram
1 gram	—	0.03527	0.03215	0.002205	0.002679	0.001
1 oz. avoir.	28.35	—	0.9115	0.0625	0.07595	0.02835
1 oz. troy	31.10	1.097	—	0.06857	0.08333	0.03110
1 lb. avoir.	453.6	16.0	14.58	—	1.215	0.4536
1 lb. Troy	373.2	13.17	12.0	0.8229	—	0.3732
1 kilogram	1.0×10^3	35.27	32.15	2.205	2.679	—

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